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MANAGEMENT APPLICATIONS OF SCALE PATTERN ANALYSIS METHODS FOR THE SOCKEYE SALMON RUNS TO CHIGNIK, ALASKA

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MANAGEMENT APPLICATIONS OF SCALE PATTERN ANALYSIS METHODS FOR THE SOCKEYE SALMON RUNS TO CHIGNIK, ALASKA[1]

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ABSTRACT

A study was conducted to determine if the two sockeye salmon *(Oncorhynchus nerka)* stocks of the Chignik Lakes in Alaska could be identified by analysis of their scale patterns. Circuli counts and linear measurements in the lacustrine zone of scales and linear discriminant functions were used to estimate the proportion of each stock present in samples of mixed stock composition. A procedure for estimating the total catch and escapement of each stock, and the age composition of each component, from age-specific stock composition estimates was developed and applied to the 1978-1982 Chignik sockeye salmon runs. The advantages of this procedure over the current method of separating the Chignik sockeye salmon stocks with an average time-of-entry curve are: (1) estimates are year-specific; (2) it separates the run by nursery lake stock; and (3) it recognizes differences in the age composition of each stock. However, specialized equipment and more effort are required for the new procedure.

An in-season procedure for estimating the stock composition of the Chignik sockeye salmon run with linear discriminant function analysis of scale patterns was developed, also. For the in-season analysis, the age 2.2 Chignik Lake standard from the year preceding the year of analysis was used to represent the age 2.3 Chignik Lake standard. The cumulative Black Lake and Chignik Lake escapement estimates for the 1979, 1981, and 1982 in-season analyses were very similar to the post-season estimates. In 1980, there was a difference of approximately 150,000 fish between the two estimates. Further evaluation of the in-season procedure is required.

KEY WORDS: Sockeye salmon, *Oncorhynchus nerka*, scale pattern analysis, salmon stock identification, Chignik sockeye run.

INTRODUCTION

The identification of stocks[1] of Pacific salmon (genus *Oncorhynchus*) by analysis of scale patterns has become a common procedure for estimating the proportion of different stocks present in areas of intermingling. Previous scale pattern studies have identified Pacific salmon stocks separated by long distances. Anas and Murai (1969) used scale patterns to determine the continent of origin of sockeye salmon caught in the North Pacific Ocean and Bering Sea. Major et al. (1975; 1977a; 1977b) performed a similar analysis of chinook salmon caught in the Bering Sea and the North Pacific Ocean. Other studies have shown that salmon stocks encompassing broad regional areas can be distinguished by scale growth patterns. The contribution of the Kamchatka Peninsula, Bristol Bay, Gulf of Alaska, and Southeastern Alaska stocks to the fishery in the North Pacific Ocean has been estimated for sockeye salmon (Marshall et al. 1978; Knudsen and Harris 1982) and coho salmon (Myers et al. 1981) by scale pattern recognition techniques.

Scale patterns have been used to separate salmon stocks within a region, also. Cook and Lord (1978) identified the river of origin of sockeye salmon from three systems in Bristol Bay. The Alaska Department of Fish and Game (ADF&G) has apportioned the annual sockeye salmon catches in Cook Inlet to the four major contributing river systems by scale pattern analyses since 1977 (Bethe and Krasnowski 1979; Bethe et al. 1980; Cross et al. 1981; 1982; 1983). Other studies by ADF&G have identified the river of origin of sockeye salmon in the Lynn Canal fishery (Marshall et al. 1982) and chum salmon in the Excursion Inlet fishery (McGregor and Marshall 1982).

Most analyses of Pacific salmon by scale patterns have separated fish from different regions or river systems. There have been few studies which separated salmon originating within a single river or lake system. In systems where there are discrete stocks contributing to the total run, efficient management requires that these stocks be identified in the catch and escapement. One analysis of this type was by Henry (1961) for the Fraser River sockeye salmon run in British Columbia. He identified the stocks of sockeye salmon in the Fraser River using scale patterns formed during the freshwater residence of the fish. The results were then used to regulate the fishery to ensure that the escapement goal for each stock was met.

Another system for which the identification of the stocks contributing to the run has been demonstrated important to management is the Chignik lakes in Alaska. The Chignik lakes watershed is located 274 km west of Kodiak Island on the south side of the Alaska Peninsula (Figure 1). The sockeye salmon run to this system is the largest in Alaska outside of Bristol Bay (average return of 2.03 million fish during 1973-1982). Effective management of the Chignik sockeye salmon run requires that the two major stocks contributing to the run be identified in the

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[1] Stock refers to all fish originating from the same geographic area. Therefore, a stock can include all salmon from a large geographic area, for example, the Kamchatka Peninsula stock, or to fish originating from a more localized area, such as the Iliamna Lake stock.

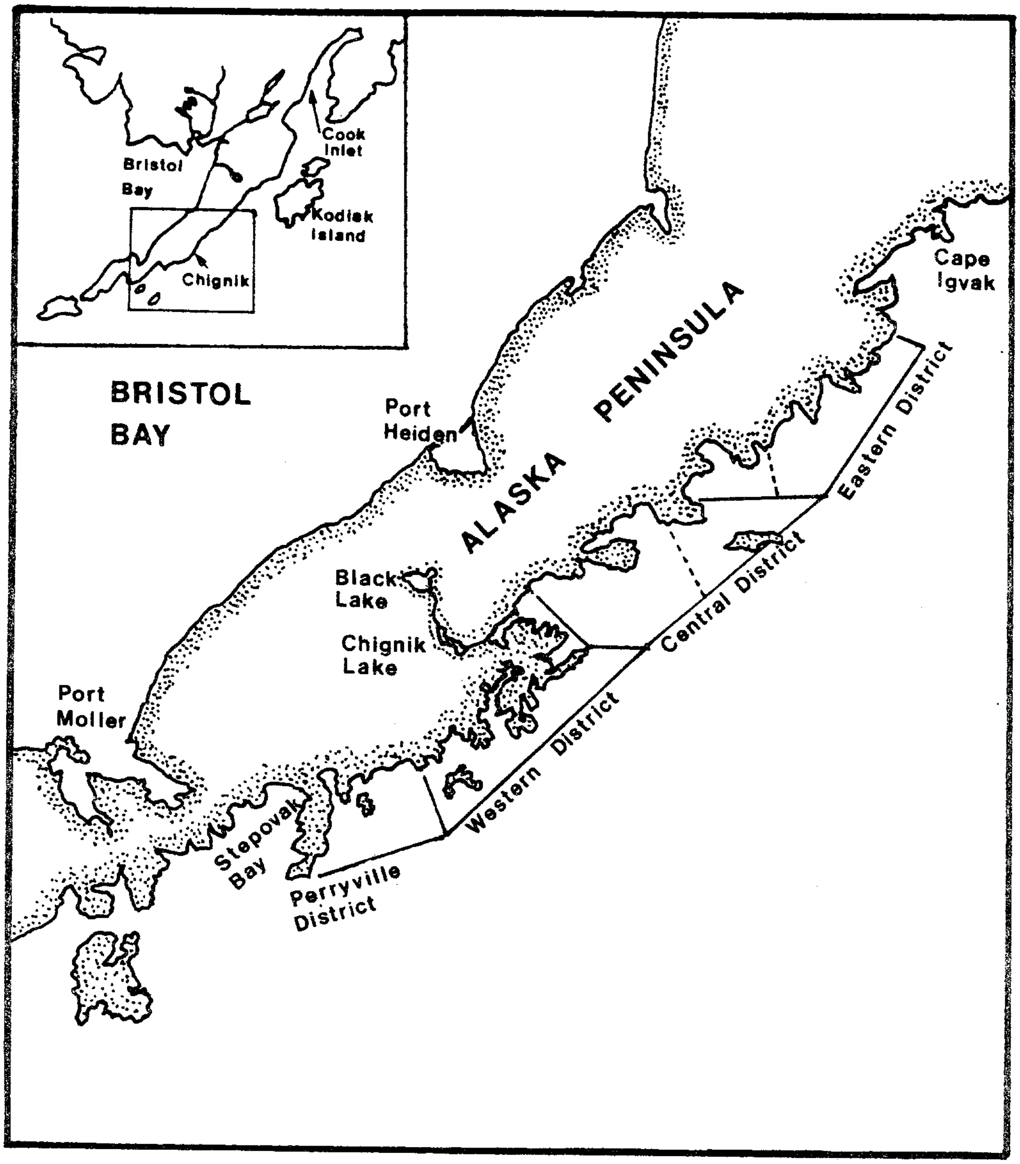

Figure 1. Map of the Alaska Peninsula showing the Chignik Management area, with an inset of western Alaska.

catch and escapement because each stock has a different spawner-recruit relationship and there are different optimum escapement goals for each stock.

The study objective was to evaluate the application of scale pattern analysis methods to the management problems peculiar to the Chignik system. Marshall et al. (1980) were able to separate one age class in 1978 sockeye salmon return to Chignik by spawning run using freshwater scale patterns. Can a similar analysis be applied to other age classes in the run allowing the two stocks to be accurately identified by scale pattern analyses on an annual basis? If so, does the scale pattern method provide sufficient advantages over the current method of separating the stocks to warrant replacing it? A background for this report is provided in the following sections by a brief description of the watershed and a literature review of previous sockeye salmon research at Chignik.

Description of the Chignik Lakes Watershed

The Chignik lakes watershed forms a natural northwest-southeast pass through the Aleutian Mountain Range on the Alaska Peninsula. The watershed covers 1,520 km^2 and consists of two lakes and their tributaries, an upper river connecting the two lakes, and a lower river emptying into a saltwater lagoon (Figure 2). Physical characteristics of the two lakes are summarized in Table 1.

Black Lake and Chignik Lake are physically dissimilar. Black Lake is shallow, warms rapidly in the spring, and is usually turbid throughout the summer. Major sockeye salmon spawning areas are in the Alec River and Fan Creek tributaries to the lake. Chignik Lake, because of its smaller surface area but much greater volume, does not experience the rapid temperature changes of Black Lake. It warms more slowly in the spring and becomes ice-free between two and four weeks later than Black Lake. Three tributaries to Chignik Lake are important sockeye salmon spawning grounds: Clark River, Home Creek, and Cucumber Creek. In addition, extensive beach spawning occurs at Hatchery Beach. A more detailed description of the Chignik lakes is provided by Narver (1966).

The two lakes are connected by Black River (12 km long), which has important spawning areas in the West Fork and Chiaktuak Creek tributaries. Chignik Lake is drained by Chignik River which empties into a nearly enclosed estuary, Chignik Lagoon. The lagoon covers about 42 km^2 at high tide, but at low tide half this area is exposed as mudflats (Dahlberg 1968).

Black and Chignik Lakes are two of the most biologically productive lakes in Alaska. They were found to have the highest photosynthetic activity and the greatest standing crop of phytoplankton of 23 sockeye salmon nursery lakes in southwestern Alaska (Burgner et al. 1969). When compared to nine other major sockeye salmon producing systems in southwestern Alaska, the Chignik system ranked second in number in spawners per unit surface area, first in chlorophyll *a* per unit volume, second in total dissolved solids, and the system had the highest concentration of a number of trace elements (Burgner, et al. 1969).

Review of Sockeye Salmon Research at Chignik

Investigation of the Chignik sockeye salmon run began in 1922 when a weir was constructed on the Chignik River to enumerate the escapement. The weir was

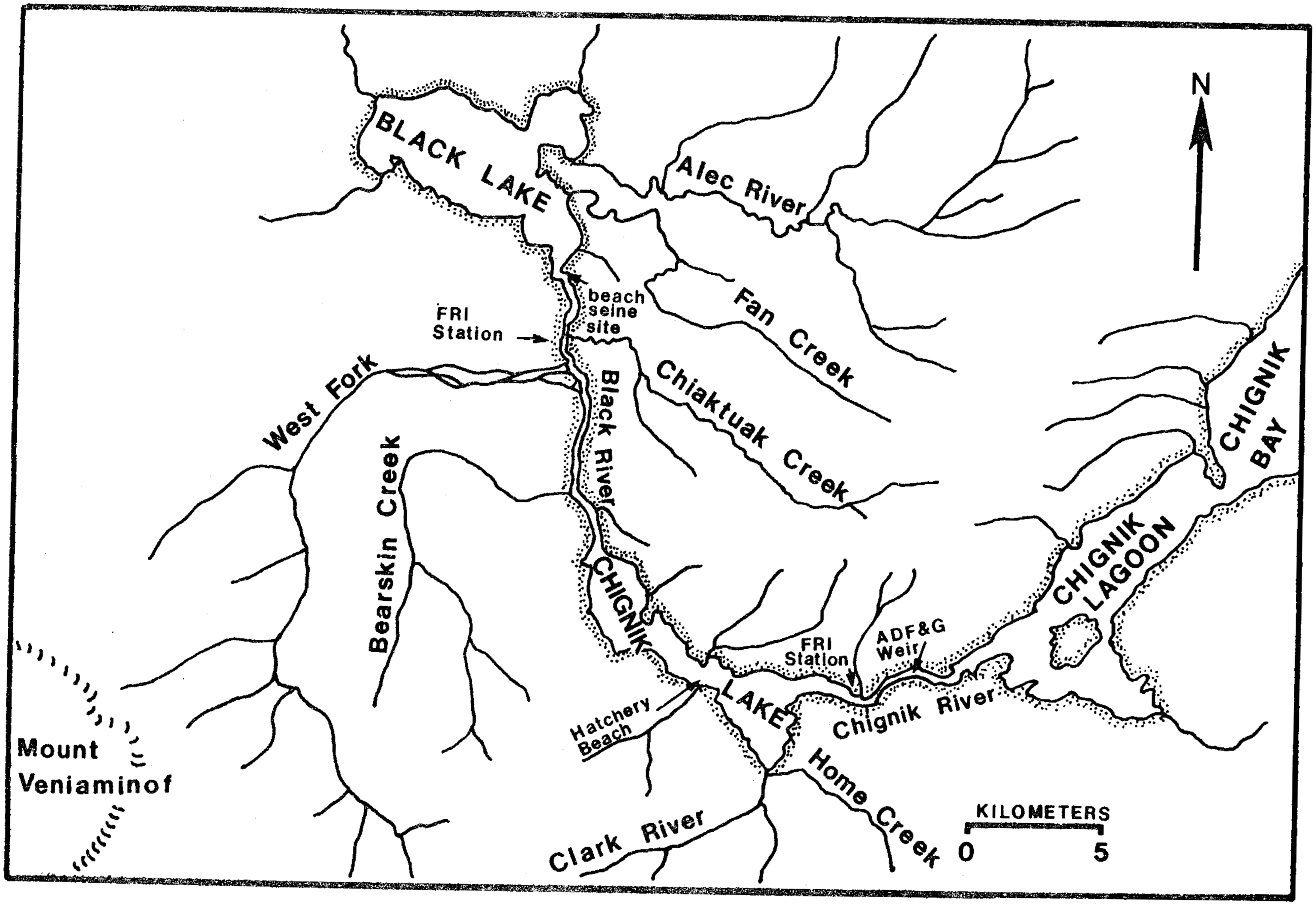

Figure 2. Map of Chignik watershed.

Table 1. Summary of the physical characteristics of Black Lake and Chignik Lake (after Dahlberg 1968).

	Black Lake	Chignik Lake
Surface area (km^2)	41.1	22.7
Mean depth (m)	3	29
Maximum depth (m)	6	64
Volume (km^3)	0.10	0.64
Sockeye salmon spawning area[1]	40 km tributary streams	35 km tributary streams, 5 km beach

[1] Source: Narver 1966.

erected annually between 1922 and 1937, and in 1939. The early research at Chignik was directed by C.H. Gilbert. It consisted of collecting scale samples from the fishery and enumerating the sockeye salmon catch and escapement. Between 1928 and 1933 research at Chignik was conducted by Harlan Holmes. He continued the earlier phases of the research and began new investigations of the freshwater life history of the sockeye salmon in the Chignik lakes. It became evident to investigators during this period that the sockeye salmon run to Chignik had more than a single component. Higgins (1932) reported,

> "The overlapping of two or more such independent runs gives the general run a complex and constantly changing age composition. This complexity apparently is increased by the existence of two independent races of red salmon supported by the spawning grounds of the two lakes in the Chignik system."

Further research on the presence of two stocks revealed that, in addition to spawning in different parts of the Chignik system, the stocks differed significantly in time of spawning migration, length of freshwater residence as juveniles, and age at maturity (Higgins 1934). Budget restrictions after 1933 curtailed the research effort at Chignik to the routine data collection of earlier years. From 1940 to 1947 the sockeye salmon run at Chignik was not monitored. Although routine data collection began again in 1948, there was no sustained research effort at Chignik until 1955.

An extensive research effort at Chignik was initiated in 1955 in response to growing concern by the Chignik fishing industry for the decline of the sockeye salmon run from previous levels of abundance. The total sockeye salmon return (catch plus escapement) declined from an average return of 1.86 million fish during the period 1922-1939, to an average return of only 0.81 million fish from 1949 to 1966 (Dahlberg 1968). The research program begun in 1955 was conducted by the Fisheries Research Institute (FRI) of the University of Washington with funding from the Chignik salmon canners. FRI has conducted research at Chignik annually since that time.

Research during the first five years of the program consisted of studies of the age composition of the runs, annual estimation of the number of smolt outmigrating, and an investigation of predation on juvenile sockeye salmon by Dolly Varden and coho salmon (Roos 1959; 1960a; 1960b). In 1961, the Alaska Department of Fish and Game assumed management control of the Chignik run and since then research at Chignik has been a cooperative effort by FRI and ADF&G.

Major advancements in understanding the dynamics of the Chignik sockeye salmon were made during the 1960s. Narver (1963) identified the spawning groups of the Chignik system by lacustrine scale pattern, time of entry into the system, time of spawning, and location of spawning (Table 2). Narver confirmed previous observations that the first segment of the Chignik sockeye salmon run, entering during June, consisted of adults bound primarily for spawning grounds in the tributaries to Black Lake and Black River. The segment of the run entering the system in July and August proved to be dominated by adults enroute to Chignik Lake spawning grounds. This explained the two peaks in abundance usually observed in the Chignik run, one occurring in June and the other in July. Narver found that, although the age composition of adults on the spawning grounds of the two lakes varied annually, most adults on Black Lake spawning grounds had spent one

Table 2. The major spawning groups of the Chignik sockeye salmon run determined by geographic area, time of entry, time of spawning, location of spawning, and location of rearing (after Narver 1963; 1966).

Group (Run)	Time of entry	Spawning characteristics Time	Spawning characteristics Location	Rearing area	Relative importance
Black Lake (early)	6/10-7/20 (peak 6/20)	7/25-8/20 (peak 8/5)	Alec R. system, Fan Cr.	Black L., age I Chignik L., age II	Major
Black Lake (late)	6/25-Aug.	8/20-Sept.	Alec R., some Black L. beaches	Unknown	Minor
Black River (early)	6/10-7/20 (peak 6/20)	7/25-8/20 (peak 8/5)	W. Fork, Chiaktuak Cr., Bearskin Cr.	Chignik L.	Major
Black River (late)	6/25-Aug.	8/20-Oct.	W. Fork, Chiaktuak Cr., Bearskin Cr.	Chignik L.	Varies
Chignik Lake (early)	6/10-7/20 (peak 6/20)	7/5-8/20 (peak 8/5)	Chignik L. beach spawning	Chignik L.	Minor
Chignik Lake (late)	6/25-Sept. (peak varies)	8/20-Oct. (peak early Sept.)	Hatchery Beach, Clark R., Home Cr., Cucumber Cr.	Chignik L.	Major

year in freshwater residence (age I) as juveniles, while a majority of adults on Chignik Lake spawning areas had spent two years in freshwater residence (age II). Other important contributions by Narver (1963) confirmed earlier evidence that progeny from Black River tributary spawning rear in Chignik Lake and that, in some years, there is a large migration of fry from Black Lake to Chignik Lake. As part of these studies, Narver also developed a consistent and objective method for measuring the lacustrine portion of sockeye salmon scales.

There were a number of ways the sockeye salmon stocks of the Chignik system could be defined from Narver's description of the spawning groups. The definition commonly used by researchers in later years classified the stocks according to the lake of residence as juveniles. Thus, fish were classified as belonging to either the Black Lake stock or the Chignik Lake stock. In years when a portion of the Black Lake fry emigrated to Chignik Lake, the emigrants were still considered to belong to the Black Lake stock because they had initially entered Black Lake after leaving the spawning grounds. This definition of the stocks is the one adopted for this report.

In response to evidence indicating that the decline of the sockeye salmon run at Chignik was due to an improper distribution of the escapement to the spawning grounds of each lake (Narver 1963), research in succeeding years was directed toward determining the optimum escapement for each lake. Independent estimates of the optimum escapements were derived by Narver (1966) and Dahlberg (1968). Narver estimated the carrying capacity of each nursery lake for sockeye salmon fry and then determined the number of adults needed on each lake's spawning grounds to produce the desired number of fry. His optimum escapement estimates were 411,000 adults for Black Lake spawning areas and approximately 200,000 for Chignik Lake spawning grounds. Dahlberg derived his optimum escapement estimates by developing conventional spawner-recruit relationships. He examined these relationships in the historic run data for the periods 1922-1939 and 1949-1966. Dahlberg estimated that the optimum escapements were 400,000 and 200,000 for Black Lake and Chignik Lake, respectively. The agreement between these two very different approaches to the problem is remarkable.

In order to calcualte the spawner-recruit relationships during the two periods examined, it was necessary for Dahlberg to separate the annual sockeye salmon return into its component stocks, Black Lake and Chignik Lake. Enumerating the catch and escapement of each stock was complicated because both pass through the same fishing area and trunk stream (Chignik River) as they return to spawn and their times of passage overlap. The technique Dahlberg devised for separating the two stocks is still being used and, since an objective of this report is to compare the current method with a technique developed later in the report, a more detailed description of Dahlberg's method will be presented.

The Dahlberg technique was based on tagging studies conducted from 1962 to 1966. Petersen disk tags were placed on approximately 250 sockeye salmon caught in Chignik Lagoon or at the counting weir during each of five or six sampling days interspersed throughout the main portion of the run (June and July). Unique tag color combinations were applied at each tagging session to identify each day. The recovery effort consisted of counting the different color combinations present on the fish in a spawning area during a single foot survey of each major spawning ground at the peak of spawning. The observed tags were then classified as belonging to either early season or late season spawners (see Table 2) and the relative proportion of each group present on each tagging date calculated.

Dahlberg's division of the run into early season and late season spawners did not strictly correspond to a division by stocks. Although most of the early-season spawners belonged to the Black Lake stock, a portion of them would spawn in Black River tributaries and their progeny rear in Chignik Lake. Therefore, the two components of Dahlberg's division of the run were termed early run and late run. The problems associated with this method of division will be discussed later.

The tagging data for each year was then fit to a logistic curve using the model

$$p = \frac{1}{1 + e^{-(a+bt)}} ,$$

where

p = the proportion of late run spawners,

$1-p$ = the proportion of early run spawners,

e = the base of Naperian logarithms,

t = the coded time (serial day), and

a and b = parameters estimated from a year's tagging data.

The values of a and b were estimated by linear regression using the transformed equation

$$a + bt = -ln \frac{1-p}{p}$$

with p and t defined as above. A time-of-entry (TOE) curve typical of those calculated in Dahlberg's analysis is presented in Figure 3. He found that the entry pattern of the runs (shape of the curves) during 1962-1966 were similar, but the actual time-of-entry (the position of the curves) changed between years. During the years of the study there was a ten day difference between the inflection points of the earliest and latest TOE curves observed.

Using each year-specific TOE curve, the sockeye salmon runs to Chignik during the years 1962-1966 could be separated into early run and late run components. To separate the run by stocks, however, an adjustment was necessary in each year of tagging to account for the portion of the early run enroute to Black River spawning grounds. This was done by using aerial surveys to estimate the proportion of the early run spawning in Black River spawning areas. The portion of the run defined as early spawners by the TOE curve was then corrected by removing the estimated Black River component, which gave an estimate of the Black Lake stock.

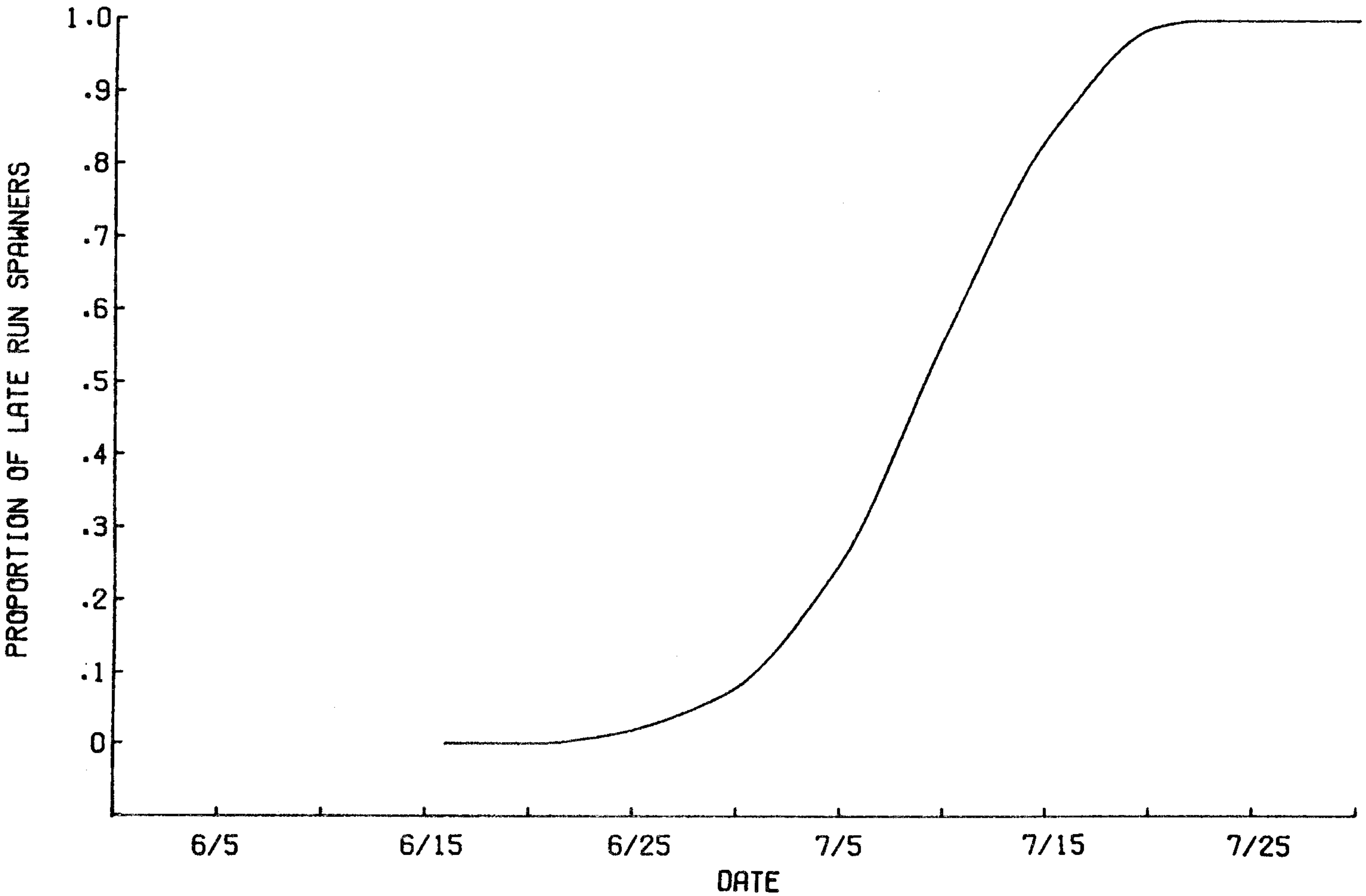

Figure 3. Example of a typical time-of-entry (TOE) curve calculated during the period 1962-1966.

It was also necessary to estimate the age composition of each stock. To do this, the scale samples collected periodically throughout the run in Chignik Lagoon or at the counting weir were used. The age composition of the run was determined for each sample date and the age composition of the run on days between sampling was estimated by linear interpolation.

To estimate the total return of each stock and its age composition for the years 1962-1966, Dahlberg's procedure was to:

1. Separate the sockeye salmon abundance (catch and escapement) for each day of the run into early run and late run components using the year-specific TOE curve.

2. Apply the age composition estimated for each day to the number estimated for the early run and late run.

3. Sum by age and by early or late run for each day of the run.

4. Correct the final early run and late run totals by the estimated contribution of Black River spawners to the early run.

This gave an estimate of the total number and age composition of each stock, Black Lake and Chignik Lake, in the total run. To estimate the stock composition of the runs prior to 1962 Dahlberg used a TOE curve which was an average of the five curves calculated from the 1962-1966 tagging data. He estimated that the average Black River contribution to the early run in those years was 13% of its total. Dahlberg then estimated the number of each stock and its age composition in the years prior to 1962 using the procedure described above. This allowed him to determine spawner-recruit relationships during the two periods previously mentioned.

The tagging studies to determine a year-specific TOE curve were continued for three more years before ending in 1970. In the years since 1969 an average curve, using the curves calculated from 1962-1969, has been used to separate the total return into its early and late run components. The range of TOE curves calculated during that period and the average curve used since then are shown in Figure 4. Occasionally, in the years since 1969, the position of the average TOE curve has been shifted to account for differences in the timing of the run as perceived by the management biologist, but the basic procedure for separating the run by stock has remained the same.

Although it provided an early, economical technique for estimating the total number and age compositon of each stock in the Chignik sockeye salmon run, researchers in subsequent years became aware of the limitations of Dahlberg's method. A major problem with the Dahlberg procedure concerned the method of estimating the age composition of each stock. During the period when both stocks were present in the catch and escapement, usually from mid-June to mid-July, the age composition samples collected were a composite of both the Black Lake and Chignik Lake stocks. Therefore, the samples did not accurately reflect the true age composition of either stock. When these age composition estimates were applied to the estimated numbers of each run, the difference between the age composition of the Black Lake and Chignik Lake stocks was moderated (Parr and Pedersen 1969; Burgner and Marshall 1974; Marshall and Burgner 1977). The

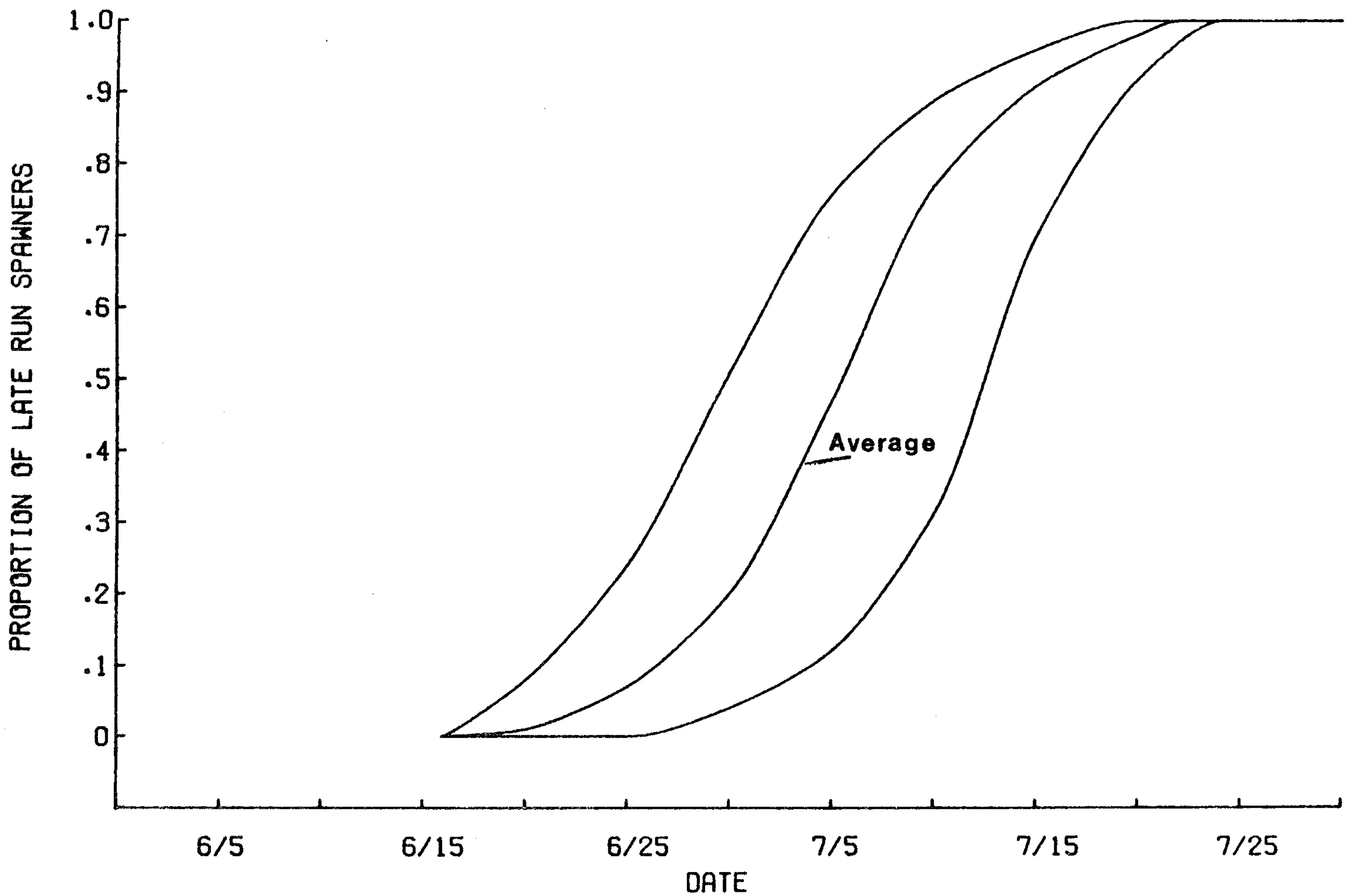

Figure 4. Earliest and latest time-of-entry (TOE) curves observed during the period 1962-1969 and the average curve for those years.

problems with the age composition estimated for each stock became apparent when the age composition of samples collected on the spawning grounds was compared to that estimated by the Dahlberg procedure. Although there are problems with a direct comparison of such data (see Discussion) the differences observed were still considered significant. Another problem with the method using the year-specific TOE curves was the assumption that the recovery effort was uniform for all major spawning grounds. In most years of tagging this assumption was not met and a greater recovery effort was expended on Black Lake spawning areas. This was complicated further by the few recoveries from Chignik Lake beach spawning. Parr and Pedersen (1969) estimated that an unequal recovery effort could shift the position of the TOE curve by as many as five days.

Research during the 1970s explored other methods of separating the Chignik sockeye salmon stocks but no satisfactory substitute was found (Marshall and Burgner 1977). Other important contributions to the understanding of the Chignik sockeye salmon run from research during the period 1969-1979 were: (1) it was determined that Chignik Lagoon was an important secondary rearing area for post-smolt sockeye salmon (Phinney 1968); (2) the technique for forecasting the return of each stock one year in advance was refined (Burgner and Marshall 1974); and (3) the difficulties in aging Chignik sockeye salmon scales were examined (Marshall 1977).

Objectives of this Study

The major objective of this study, as previously stated, was to determine if the two sockeye salmon stocks of the Chignik watershed could be identified by their scale patterns. The sampling procedures, analytical techniques, and method of estimating the daily age and stock composition of the run will be described in the following section. The scale pattern method of separating the stocks was evaluated by comparing it to the procedure currently used.

A second objective was to determine if the scale pattern method could be applied during the summer when the run was in progress. This in-season application is needed to estimate the numbers of each stock in the escapement, which is required by the management biologist to ensure that the escapement goal for each stock is met.

In addition, a number of hypotheses concerning the Chignik sockeye salmon run, some which have important management implications, were tested by scale pattern analyses.

MATERIALS AND METHODS

This study was initiated in 1981 and the scale sampling efforts at Chignik during the summers of 1981 and 1982 were designed to satisfy the requirements of the study. To completely evaluate the scale pattern technique and its applications, however, an analysis of more than two years of data was desired. Fortunately, the scale samples collected at Chignik during 1978, 1979, and 1980 were sufficient for the analysis. The collection of scale samples prior to 1981 was occasionally less frequent than during the years of the study, but there were no serious deficiencies in the data. Therefore, the post-season analysis of the Chignik run by scale patterns was for the years 1978-1982. The in-season analysis presented other problems because of its unique requirements. An in-season analysis was simulated for the years 1979-1981 and an actual in-season analysis was conducted in 1982. The next section of the report describes the procedures used in 1981 and 1982 to collect the scales and prepare them for analysis. Similar procedures were used in 1978-1980 and any significant departures during those years is noted.

Collection of Scale Samples and Preparation for Analysis

A standard procedure was used to collect the sockeye salmon scales and prepare them for analysis. The procedure used is the accepted method for salmon scale studies and is an adaptation of the procedures described in Koo (1955) and Clutter and Whitesel (1956). Briefly, the preferred scale, or a scale near it, was removed from the left side of each fish sampled. The preferred scale is located on the diagonal scale column between the posterior edge of the dorsal fin and the anterior edge of the anal fin and is the second scale above the lateral line (Clutter and Whitesel 1956). Scales of young salmon first develop in this area. Each scale was cleaned between the fingers, moistened, and mounted on a gummed card. The sex and mideye-to-fork-of-tail length measured to the nearest millimeter was recorded for each fish sampled on an age-weight-length (AWL) form. Thirty or 40 scales were mounted on each gummed card. Scales removed from outside the preferred area were noted on the AWL form but prior to 1981 this was not done. A permanent impression of each gummed card was made in cellulose acetate. This allowed the image of each scale to be projected by transmitted light for aging and measuring purposes.

A sample size of 200 scales is desired for age determination and scale measurement studies (Clutter and Whitesel 1956). The presence of regenerated or unreadable scales in any sample requires that more than 200 scales be collected. To ensure that 200 scales were available for analysis, approximately 300 scales were usually collected during each sampling session. Prior to 1981 smaller samples were occasionally collected.

Most of the scale samples necessary for this study were collected at two locations, Chignik Lagoon and the outlet of Black Lake. Scale samples to monitor the age and stock composition of the run were periodically collected in Chignik Lagoon throughout June, July, and August. During the critical period of transition from a majority of Black Lake stock in the run to a majority of Chignik Lake stock, samples were usually collected about every third day. Scale samples were collected from catches delivered to tenders in Chignik Lagoon when the commercial fishery was operating. Commercial fishing in the Chignik management area is exclusively by purse seine boats. Much of the fishing effort for the area is concentrated in Chignik Lagoon where between 60 and 70 boats operate during the height of the run. When the fishery was closed and scale samples were needed, ADF&G chartered a vessel for a test fishery to collect the necessary samples. The catches from two or three boats were usually subsampled when scales were collected on the tenders. The catches from two or three areas of the Lagoon were subsampled when a test fishery was conducted.

Scale samples were routinely collected each year at the outlet of Black Lake (Figure 2). Marshall and Burgner (1975) had previously found that adults in the Black Lake escapement congregate in this area for extended periods of time before migrating to Black Lake spawning grounds and could be sampled using a beach seine. Approximately 1,200 scales were collected during four or five sampling trips to this site during each year. Sampling the Black Lake escapement for scales was restricted to two or three weeks in June and early July because: (1) beach seining at the outlet was not productive until at least 150,000 fish had been counted past the weir on Chignik River; and (2) scale samples collected after the first week of July had large numbers of scales with resorbed margins which could not be used in the analysis.

Age Determination of the Scale Samples

The difficulties in determining the freshwater age of Chignik sockeye salmon from their scales were recognized by the earliest investigators. Higgins (1930) reported, "The scales present irregularities that cannot be interpreted with certainty until a detailed study has been made of the growth of the fingerlings and the development of their scales." Problems with determining the freshwater age can be attributed to three facets of the freshwater life history of Chignik sockeye salmon:

1. Newly emerged fry are found in Chignik Lake throughout the summer and often the late emerging fry deposit only two or three circuli before growth ceases. This usually results in an indistinct first annulus (Narver 1963; Phinney 1948).

2. In years of a large fry emigration from Black Lake to Chignik Lake, scales of the emigrants may exhibit confusing patterns (Marshall 1977).

3. Nearly all smolts spend time in Chignik Lagoon and sometimes it is difficult to distinguish scale growth which occurred in the lagoon from normal freshwater growth (Phinney 1968).

As a result, determining the freshwater age of many scales is subject to a great degree of individual interpretation. Previous studies have documented the high between-reader variability in determining the freshwater age of Chignik sockeye salmon scales (Narver 1963; Phinney 1968; Marshall and Burgner 1977). To eliminate this source of variation, the author aged all the scales used in the study.

To test if age interpretations were consistent throughout the study, three large samples were re-aged about one year after the initial reading and the age compositions compared. The samples re-aged were the 1978 and 1980 samples collected at the outlet of Black Lake and the 1980 samples collected in Chignik Lagoon.

Narver (1963) and Marshall (1977) had previously investigated the problems with interpreting the lacustrine annuli on Chignik sockeye salmon scales. These studies sampled the scales of juveniles from specific brood years throughout their freshwater residence, from emergence to outmigration. By collecting scales of known lacustrine age in each lake, they were able to examine the different scale patterns associated with each lacustrine age group. This report adapted the criteria established by these studies for interpreting the lacustrine age. Narver's criteria for designating lacustrine annuli were: (1) any narrowing of circuli and/or the space between circuli; and (2) "cutting over" of the first circulus of the new year's growth. Marshall concluded that, in addition to these criteria, "all relative minimums (decrease in distance between circuli) in the lacustrine portion of Chignik sockeye scales should be accepted as true annuli if such minimums are accompanied by changes in either the types or boldness of circuli." Marine annuli were usually very distinct and there were rarely problems with determining the marine age.

The scale impressions were projected at 82X on a standard microfiche reader for aging. A preliminary age reading of all scales in a sample was made at this magnification and an age assigned to all readable scales. Scales displaying any regeneration or scale images too indistinct to interpret with confidence were omitted from the analysis. During the preliminary reading, there was occasionally uncertainty in the lacustrine ages assigned to some scales because of confusing scale patterns. These scales were marked and later examined at 210X (the magnification used for measuring the scale features) to verify the assigned age. Usually 10-15% of the scales in a sample required examination at the higher magnification. This proved to be an efficient procedure for accurately aging the large numbers of scales required for this study. All ages were recorded in the European formula as defined by Koo (1962)[1].

Scale Measurement Procedure

The scale features measured for this analysis were restricted to the lacustrine zone of the adult scales collected. Any differences in scale patterns between the two Chignik sockeye salmon stocks should be most evident in this zone because of the different environmental conditions that each stock experienced in its associated nursery lake. The marine growth of the scales of the two stocks should be similar because their time of outmigration overlaps and their ocean migrations are assumed to be similar. Previous research had confirmed that differences existed between the lacustrine scale patterns of the stocks. Narver (1963) found differences in lacustrine scale growth patterns between the spawning groups of each lake in the Chignik system, and Marshall et al. (1980) used measurements made in the lacustrine zone to separate the 2.3 age class by run in the 1978 return to Chignik.

Previous studies have established that an axis approximately perpendicular to the anterior edge of the unsculptured posterior field is best for consistently measuring sockeye salmon scales (Clutter and Whitesel 1956; Narver 1963). This axis is approximately 20° dorsal or ventral from the anterior-posterior axis (Figure 5). All circuli counts and scale measurements in the lacustrine zone were made along this axis. The scale impressions were projected at 210X and the distance from the center of the scale focus to the outer edge of each circulus in each annular zone was measured. The number of circuli and width of any freshwater plus growth were measured also. Plus growth is defined as scale growth after the last lacustrine annulus and before the onset of marine growth (Mosher 1969). Annular zones were identified by the criteria previously described for age interpretation. The criteria for deciding which circuli to count and measure in an

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[1] European formula: number of freshwater annuli, decimal point, number of marine annuli. The total age in years is the sum of these two numbers plus one.

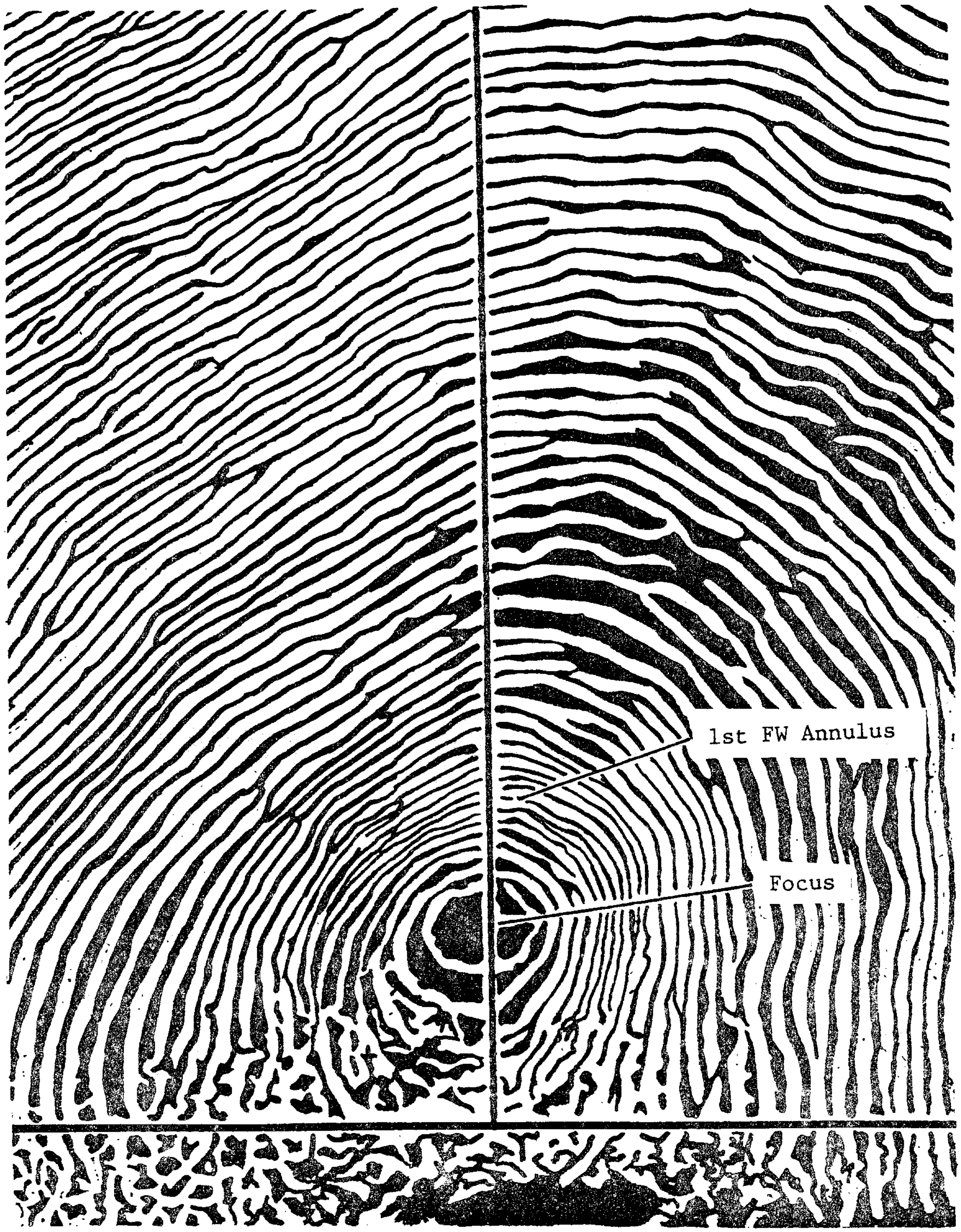

Figure 5. Section of an age 1.3 Chignik sockeye salmon scale showing the position of the measurement axis (97X).

annular zone were those of Tanaka et al. (1969), which are illustrated in Figure 6. Regenerated scales, scales which were not from the preferred area, or scales with a poor impression in the acetate were not measured.

All measurements of scale features were made using a microcomputer-based scale digitizing system developed at FRI. This system is designed to eliminate most of the laborious and error-prone steps of measuring scales and enable rapid and accurate processing of large numbers of scales. The scale image is projected on an electronic digitizing surface and the coordinates of the scale characters being measured are entered with a hand-operated free-cursor. The coordinate sets are processed by a microcomputer interfaced with the digitizing tablet and the linear distance to each circulus from the scale focus calculated to the nearest 0.001 inch. Data describing the sample being processed (sample number, sex, length, age, etc.) is entered on a keyboard connected to the computer. The information describing each sample, the distance to each circulus in each annular zone, and summary data, total number of circuli and width, for each annular zone and the plus growth zone (if present) are formatted and recorded on a flexible magnetic disk (Appendix Tables 1a and 1b).

Analytic Procedures Used to Identify the Chignik Sockeye Salmon Stocks by Their Scale Patterns

The ability to recognize salmon stocks by their scale patterns depends upon the degree of difference between the scale characters examined for the stocks and the analytic technique. Various discriminant function analyses have traditionally been used to separate salmon stocks by their scale patterns. The most commonly used procedure has been the linear discriminant function (Anas and Murai 1969; Bilton and Messinger 1975; Bethe and Krasnowski 1979). Quadratic discriminant functions (Anas and Murai 1969), polynomial discriminant functions (Cook and Lord 1978), and direct density estimation procedures (Cook 1982a) have been used, also. Linear discriminant function (LDF) analysis was selected for this report because: (1) Marshall et al. (1980) used an LDF in their scale pattern analysis of the Chignik sockeye salmon stocks and were able to identify the stocks with greater than 80% accuracy; (2) existing programs for performing an LDF analysis are readily available (for example BMDP7M, Dixon and Brown 1979); and (3) it was necessary to perform the scale pattern analyses on a microcomputer and the procedures for performing an LDF analysis could be easily programmed in FORTRAN.

The LDF is a multivariate technique for constructing a classification scheme to assign a previously unclassified observation to an appropriate group. The LDF is the linear combination of p observed variables which maximizes the between-group variance relative to the within-group variance (Fisher 1936). Consider two independent random samples each drawn from a p-variate normal distribution. If $\bar{\mathbf{x}}_1$ and $\bar{\mathbf{x}}_2$ are the sample mean vectors for each group and $\mathbf{S}$ the pooled sample variance-covariance matrix, then the coefficients of the sample LDF are estimated by

$$(\bar{\mathbf{x}}_1 - \bar{\mathbf{x}}_2)'\mathbf{S}^{-1} .$$

The allocation rule for determining the group membership of an unknown observation, $x = (x_1, x_2, \ldots x_p)'$, depends on

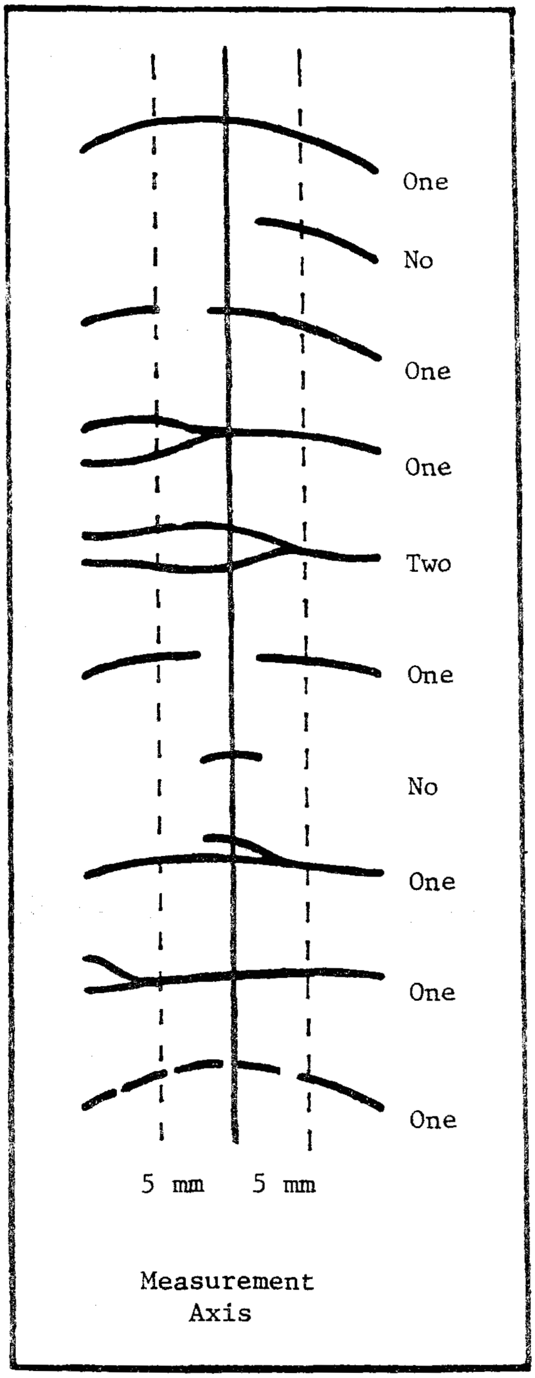

Figure 6. Diagrammatic representation of a section of a scale (projected at 210X) indicating the criteria for inclusion of circuli counts and measurements along the selected axis. "One" and "two" indicate the number of circuli that would be included in counts and for which positions would be marked for measurement. "No" indicates that the circulus would not be included in counts and its position would not be measured (after Tanaka et al. 1969).

$$w = (\bar{x}_1 - \bar{x}_2)'S^{-1}\{x - 1/2(\bar{x}_1 + \bar{x}_2)\}.$$

The unknown observation is then assigned to a group depending on the value of w and some cut-off point, which is frequently taken as zero. The major assumptions underlying LDF analysis are: (1) the groups being investigated are discrete and identifiable; (2) the variables used to determine group membership have a multivariate normal distribution in each population; and (3) the variance-covariance matrices for the groups are equal.

Previous studies which have separated stocks of salmon using scale patterns and LDF analysis did not test the fit of the scale measurement data to the assumptions underlying the LDF. One assumption which can be tested is that of the equality of variance-covariance matrices for the populations being separated. Box (1949) described a procedure for testing the equality of variance-covariance matrices using the F statistics. This procedure was used to test the equality of variance-covariance matrices for all the LDF analyses of the Chignik sockeye salmon scale measurement data.

Once an LDF has been calculated, its accuracy in assigning observations of unknown origin to the correct group must be determined. Most investigators involved in salmon stock identification estimate error rates by dividing the data for each sample of known origin into two subsamples. One subsample is then used to construct the discriminant function(s) and the remaining data is classified using that discriminant function. By observing the proportion of the second subsample misclassified, the error rates can be estimated. Cook (1982a) noted that this procedure required fairly large sample sizes, which are not always available, and it was not an efficient use of the entire sample. Cook suggested that the leaving-one-out method proposed by Lachenbruch (1967) was more appropriate. This method uses all observations and gives nearly unbiased estimates for the probabilities of misclassification. The classification accuracy is estimated by removing one observation from the data, constructing a discriminant function using all remaining observations, and classifying the omitted observation with the discriminant function. This is done for all observations and the results tallied. The probability of misclassification for each group can then be calculated. The leaving-one-out procedure was used to estimate the classification accuracies of all LDF analyses performed for this study. An inverse matrix adjustment procedure (Bartlett 1951) was used in the program which performed the LDF analysis on the microcomputer. This significantly reduced the time required by the microcomputer to perform the leaving-one-out procedure by requiring only a single matrix inversion.

In studies separating stocks of salmon by their scale patterns the goal is usually not to identify the origin of individual salmon but to estimate the proportion of different stocks present in an area of intermingling. The origin of each observation in a sample consisting of a mixture of stocks can be determined using the appropriate LDF and the proportion of each stock present can be calculated. Worlund and Fredin (1962) noted a set of linear relationships which adjust the proportional estimates from the mixed samples to account for the classification errors of the assignment rule. Cook and Lord (1978) formulated this approach in matrix notation and applied it to a salmon stock identification problem. They found by simulation that the classification matrix correction procedure improved the estimate of the true proportion of each stock present. Using the notation of

Cook and Lord, let the classification accuracy estimated by the leaving-one-out procedure be represented by the matrix $\hat{C}$, where the element c_{ij} is the fraction of the population from stock j that is classified as stock i. Let $\hat{r}$ be a vector with elements r_1, r_2, ..., where r_1 is the proportion of the mixed population classified as stock i. Then

$$\hat{u} = (\hat{C})^{-1}\,\hat{r},$$

where each element u_i is the corrected estimate of the proportion of stock i in the sample composed of a mixture of stocks.

Variance formulae for the estimates of $\hat{u}$ have been proposed by Worlund and Fredin (1962), Pella and Robertson (1979), and Cook (1982b). Cook (1982b) noted that all proposed formulae require that $\hat{r}$ and $\hat{C}$ be statistically independent, which is never true in practice. Simulation studies by Cook revealed the variance formulae of Pella and Robertson (1979) lead to conservative confidence intervals when $\hat{r}$ and $\hat{C}$ are independent. He felt that, due to the conservative nature of the formulae, their use was justified. Therefore, all variances for the proportional estimates of the stock composition of mixed samples were derived using the formulae of Pella and Robertson. When only two stocks are present in the mixture, as was the case for this study, confidence intervals can be calculated using the variance estimate and the univariate normal approximation (Pella and Robertson 1979).

Scale Characters Examined and Selection Procedure for Use in the LDF

The discriminating power of the LDF is a function of the variables used to construct it. The greater the difference between the populations for the variables used in the LDF, the higher the classification accuracy. The patterns of circuli and annuli on a scale reflect the growth history of an individual. The basis for separating stocks of salmon by their scale patterns is the difference in the growth histories of each stock. The degree to which the characters measured from the scale reflect the differences in growth between the stocks determines the accuracy of the LDF in separating the stocks.

The scale characters examined for this study included those recorded directly from each scale; the width and number of circuli in each lacustrine annular zone and in the zone of lacustrine plus growth (if present), and the distance from the center of the scale focus to each circulus in each lacustrine annular zone; and combinations of these characters. Differences in scale growth which could be useful in discriminating between stocks could appear during any period of the freshwater life history. Therefore, within each annular zone the width of and number of circuli in a number of specific areas distributed throughout the zone were examined. Other scale characters which reflect growth were generated by expressing the scale growth within a specific area in an annual zone as a fraction of the total width of that zone. A total of 62 scale characters in each lacustrine annual zone (first or second) and six characters in the zone of lacustrine plus growth, if present, were generated from the basic set of measurements made on each scale (Appendix Table 2).

Sex as a possible source of variation in scale characters has been examined in previous sockeye salmon stock separation studies by Anas and Murai (1969) and

Bilton and Messinger (1975). They found no significant differences between males and females for the scale characters they examined. These studies used scale characters in the lacustrine and marine zones, but did not examine the lacustrine zone in the detail of this study. Also, these studies tested for differences in scale characters between the sexes on the univariate level and their conclusions may not apply to the multivariate case. Since LDF analysis is a multivariate procedure, a multivariate test for differences in scale characters between males and females would be more appropriate.

A procedure for testing the equality of means between two groups for more than one variable uses the Hotelling T^2 statistic (Morrison 1976). This test is also used for the in-season analysis, so its development will be described. The assumptions underlying this multivariate procedure are similar to those for LDF analysis, the two samples are assumed to be drawn from multivariate normal populations with a common covariance matrix. The Hotelling T^2 statistic is

$$T_2 = \frac{N_1 N_2}{N_1 + N_2} (\bar{\mathbf{x}}_1 - \bar{\mathbf{x}}_2)' \mathbf{S}^{-1} (\bar{\mathbf{x}}_1 - \bar{\mathbf{x}}_2)$$

where N_1 and N_2 are the sample sizes for the groups being test, $\bar{\mathbf{x}}_1$ and $\bar{\mathbf{x}}_2$ are vectors of means for the variables being compared for each group, and S is the pooled variance-covariance matrix estimated from the sample data. The test statistic is

$$F = \frac{N_1 + N_2 - p - 1}{(N_1 + N_2 - 2)p} T^2$$

which has the variance ratio F distribution with degrees of freedom p (number of variables) and $N_1 + N_2 - p - 1$.

If the null hypothesis H_0: $\bar{\mathbf{x}}_1 = \bar{\mathbf{x}}_2$, is rejected, those variables which contribute most of the difference between the groups can be determined by constructing Roy-Bose simultaneous confidence intervals around the differences between the means (Morrison 1976). This procedure is superior to examining the difference between mean values for the groups using a univariate t-test because it protects against the tendency for individual differences to be significant merely by chance as more responses are included and it accounts for the effects of positive correlations among the subtests. The Roy-Bose simultaneous confidence intervals are constructed for the difference between the mean values of the variables for each group by

$$(\bar{\mathbf{x}}_{1i} - \bar{\mathbf{x}}_{2i}) \pm (s_{ii})^{1/2} \left(\frac{N_1 + N_2}{N_1 N_2} F_{\alpha;p,N_1 + N_2 - p - 1}\right)^{1/2},$$

$$i = 1, 2, \ldots p.$$

where s_{ii} is the ith diagonal element of $\mathbf{S}^{-1}$.

Those variables which do not include zero in the confidence interval around the difference between their means are the variables contributing most to the difference between the two groups.

The Hotelling T^2 statistic performs best when a limited number of variables are tested simultaneously for equality between groups. To test the hypothesis that scale growth is the same for males and females, a manageable subset of all the scale characters generated had to be selected. The basic scale measurement characters in each lacustrine annular zone were selected for testing because most of the other scale characters generated were linear combinations of these basic measurements. The scale characters tested were the mean width of and mean number of circuli in each lacustrine annular zone, the mean distance from the center of the scale focus to each of the first five circuli in the first annual zone, and (if present) the mean distance from the end of the first lacustrine annulus to each of the first five circuli in the second annular zone. Each annular zone was tested separately to limit the number of variables tested simultaneously to seven for each annular zone. Incomplete cases, scales which had less than five circuli in an annular zone, were omitted from the analysis of that zone.

Each standard used in an LDF analysis was tested for equality of scale characters between males and females. As was done for each LDF analysis, the equality of the variance-covariance matrices for the sexes was tested using Box's procedure to examine how well that assumption was met. When a significant difference was found between the scale characters of males and females, Roy-Bose 95.0% confidence intervals around the differences between the means were constructed to determine which variables were responsible for the significance of the test.

A great variety of techniques have been used to select the "best" subset of variables for a discriminant analysis. When only two populations are involved the problems associated with selecting a subset of variables for an LDF analysis are greatly reduced. For the two group problem, a stepwise procedure using the F statistic to determine entry into the LDF will provide a "best" subset for discrimination (Habbema and Hermans 1977). The program BMDP7M (Dixon and Brown 1979) provides a procedure which uses the F statistic to select a subset of variables for an LDF. This program sequentially enters the variable with the highest partial F-value, calculates an LDF using the variable entered and any variables previously entered, and determines the classification accuracy of the LDF. This procedure continues until the partial F-values for the variables not entered are below a user-specified cut-off.

All the scale characters generated for each freshwater age group could not be screened simultaneously using BMDP7M because of memory limitations. To reduce the 68 possible scale characters for age I fish and 130 possible scale characters for age II fish to a manageable subset, a preliminary analysis of the characters was conducted. The F-value for all scale characters and the correlation coefficient for each pair of characters were calculated and a subset of approximately 30 variables was then selected for each analysis. The scale characters selected had either a large F-value or were negatively correlated with characters having large F-values. Variables selected using these criteria will usually contain a subset which will give the "best" LDF (Cochran 1964). The characters selected by this procedure were then used in BMDP7M with the F-to-enter level set to 4.0. The "best" subset of characters for discriminating between the two stocks was then selected by the program with the previously described procedure. An F-to-enter value of 4.0 usually corresponded to an α level between 0.025 and 0.050 for the sample sizes used in the analyses. McLachlan (1980) stated that with a conservative α level such as this, there can be a fairly high degree of confidence that the overall error rate is not increased by the selection decisions of the F test.

METHODS FOR POST-SEASON ANALYSES

Estimates of the numbers and age composition of the components of the Chignik sockeye salmon run, i.e., the catch and escapement of the Black Lake and the Chignik Lake stocks, are necessary to: (1) evaluate the effects of regulating the commercial fishery; (2) determine the spawner-recruit relationships for each stock; and (3) forecast the return of each stock in subsequent years. The purpose of the post-season analyses was to estimate the numbers and age composition of each stock in the catch and escapement. This section describes the method developed for the post-season analyses.

Estimating the Daily Sockeye Salmon Abundance in Chignik Lagoon

The scale samples used to estimate the stock and age composition of the Chignik run were collected in Chignik Lagoon. The commercial catch in areas outside of the Chignik Lagoon and the escapement to Chignik River had to be adjusted to coincide with the daily catch in the Lagoon before the stock and age composition estimates could be applied. Previous tagging studies determined that nearly all sockeye salmon intercepted by the commercial fishery in the Chignik management area were enroute to the Chignik system (Roos 1960b; Dahlberg 1968; Lechner 1969). Therefore, the ADF&G allocates all sockeye salmon caught in the Chignik management area to the Chignik run. In addition, the tagging studies found that a substantial portion of the sockeye salmon caught by the purse seine fishery at Cape Igvak (Figure 1) were of Chignik origin. Traditionally, 80.0% of the Cape Igvak sockeye salmon catch has been allocated to the Chignik run and that procedure was followed for this report.

Catches in the districts outside of Chignik Lagoon were adjusted to allow for the migration time to the Lagoon before the stock and age composition estimates were applied to them. Average migration times to the Lagoon were estimated for each of the ADF&G fishing districts in the Chignik management area. Two districts were modified slightly to allow different migration times within the district (Figure 7). The Central district was divided into two smaller areas, Hook Bay/Kujulik and Aniakchak, and its eastern boundary extended. The migration time from each area to Chignik Lagoon was estimated from the results of the previous tagging studies. The migration times were estimated as being: Hook Bay/Kujulik, 1 day; Aniakchak, 2 days; Western, 2 days; Eastern, 3 days; Perryville, 3 days; and Cape Igvak, 5 days. These are average migration times and are realized to be gross approximations. They were not felt to be a major source of error in estimating the total daily catch, however, because the catch in areas outside the combined Chignik Lagoon-Hook Bay/Kujulik areas averaged less than 15% of the total catch for the years 1978-1982 (Table 3).

It was also necessary to adjust the escapement counts at Chignik weir to account for the migration time from the Lagoon to the weir. Roos (1960b) and Dahlberg

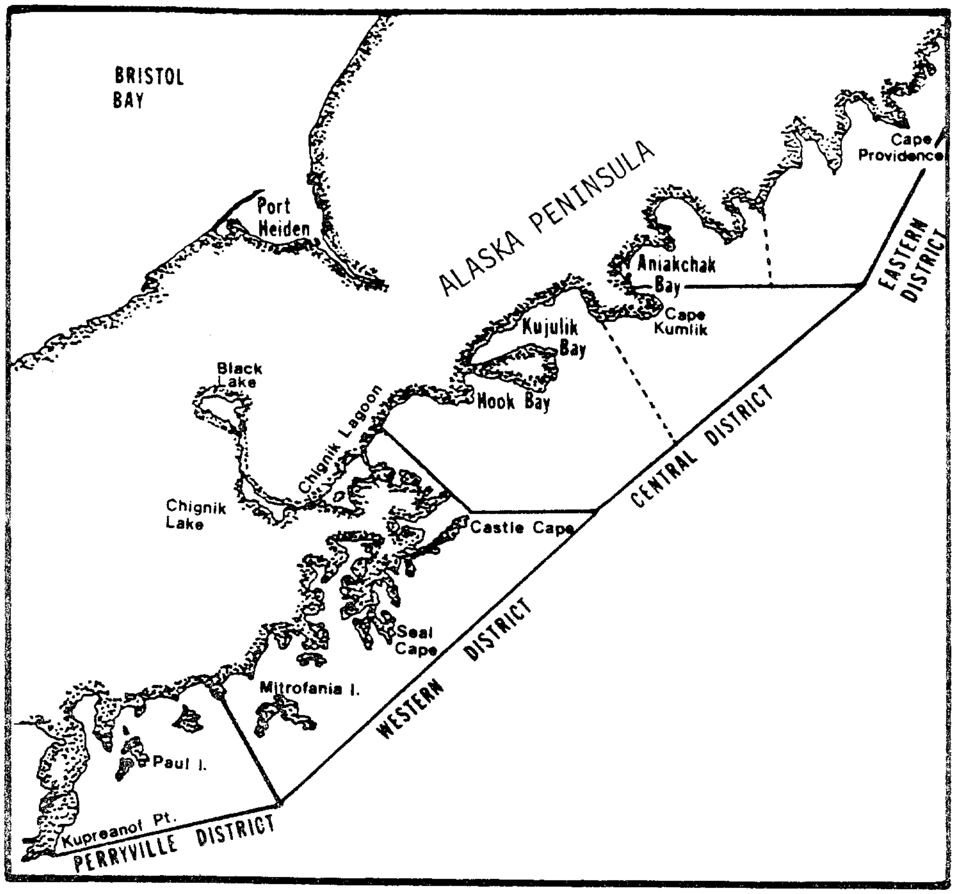

Figure 7. Map showing the modifications to the Alaska Department of Fish and Game fishing districts for the Chignik area.

Table 3. Percentage of the total Chignik sockeye salmon catch caught in Chignik Lagoon and in the combined Chignik Lagoon-Hook Bay/Kujulik areas, 1978-1982.

	Sockeye salmon catch				
Year	Total	Chignik Lagoon	%	Chignik Lagoon-Hook Bay/Kujulik	%
1978	1,821,053	1,474,673	81.0	1,512,370	83.0
1979	1,064,029	908,405	85.4	945,036	88.8
1980	860,415	708,828	82.4	779,977	90.7
1981	2,110,893	1,343,680	63.7	1,631,539	77.3
1982	1,676,864	1,400,770	83.5	1,472,758	87.8
Mean			79.2		85.5

(1968) both used a lag time of two days from the Lagoon to the weir. They based their estimate on tagging experiments conducted in Chignik Lagoon when the fishery was closed. This may not be an accurate estimate, however. When the fishery was closed during a period of large daily escapements, a significant decrease in the escapement was typically observed one day after the fishery in the Lagoon began again. When the fishery was opened for an extended period, the correlation between the number caught in Chignik Lagoon and the escapement one day later was consistently better than a correlation using the escapement two days later (Conrad, unpublished data). The intense commercial fishery in the Lagoon appears to herd the fish through the lagoon and, because of this "flushing" effect, a one day migration time from Chignik Lagoon to the weir was decided to be more appropriate.

Since 1979 the weir on Chignik River has been removed on 1 August. An August escapement of 50,000 sockeye salmon has been estimated by the Alaska Department of Fish and Game for each of the years 1979-1982. This estimate was divided equally among the days in August to determine the daily Chignik Lagoon abundance in August.

<u>Constructing the LDFs for Estimating the Stock Composition in Chignik Lagoon</u>

An LDF analysis requires a representative sample (a standard) of each group to be separated in the analysis. The standards for the Black Lake stock consisted of scales randomly selected from those collected by beach seining at Black Lake outlet. Constructing the Chignik Lake standard in a similar manner was not possible because: (1) there is no area where large numbers of Chignik Lake spawners accumulate (outside of Chignik Lagoon) where they are available for sampling; and (2) the Chignik Lake spawners do not move onto the spawning grounds until late in the season (September and October) after the field research has ended.

Scales to construct the Chignik Lake standards were selected from the samples collected in Chignik Lagoon. Scales were randomly selected from samples collected in the Lagoon on 24 July or later to construct the standards required for the years 1978-1982. During the years of tagging to estimate the Dahlberg TOE curve, spawners were never assigned to the Black Lake stock later than 21 July. In the years of this study, more than 80% of the total run (adjusted to Chignik Lagoon date) had occurred by the time the first sample to be used as a Chignik Lake standard had been collected. Probably very few Black Lake spawners, if any, would be present in this last segment of the run to arrive.

A major criticism of the Dahlberg method of separating the Chignik sockeye salmon stocks was its failure to recognize differences in the age composition between the stocks by applying a single stock composition estimate to all age classes. To avoid this, an LDF specific to each of the major age classes in the run for each of the years 1978-1982 was constructed. Historically, the 1.3 and 2.3 age classes dominate the Chignik sockeye salmon run. Combined, these two age classes usually account for more than 80% of the total run in any year. The 2.2 and 1.2 age classes, respectively, are next in importance. The contributions of other age classes are minor.

A sample size of 200 scales was desired for each set of standards (Black Lake and Chignik Lake) required for an age class. Unfortunately, 200 scales of the necessary age were not always available and it was often necessary to use smaller sample sizes. If less than 25 scales for an age class were available for a standard, an LDF analysis was not conducted for that age class. The classification accuracy of each age-specific LDF was estimated using the leaving-one-out procedure.

Estimating the Daily Stock Composition in Chignik Lagoon

The scale samples collected in Chignik Lagoon during the period of transition (approximately 15 June to 20 July) were used to estimate the proportion of each stock present in the catch and escapement. Scale measurements for each age class analyzed were taken from a maximum of 100 scales of those available on a sample date. If less than 15 scales for an age class were available that age class was not analyzed for that sample date.

An LDF was constructed for each of the age classes available in sufficient numbers for analysis. For each age class analyzed, the samples of unknown stock composition were then classified using the appropriate age-specific LDF. The estimates of the proportion of each stock present in an age class were adjusted by the classification matrix correction procedure and the variance of each of the estimates was calculated.

Once the stock composition estimates for an age class were calculated they could be applied to the daily catch and escapement totals in a number of ways. Three methods of applying the estimates were considered: (1) apply the adjusted estimates for a sample date as they were; (2) generate a smooth curve by following a procedure similar to that used to determine a Dahlberg TOE curve; and (3) smooth the estimates over a number of sample dates. In a preliminary analysis (Conrad 1982), large differences in stock composition estimates for an age class were observed in samples only two or three days apart. This could be attributed to an unrepresentative scale sample collected in Chignik Lagoon than to a real change in the stock composition of the magnitude observed. This problem will be discussed more thoroughly in a later section (see Discussion). It was felt that using the estimates as they were was not appropriate because of the danger of an unrepresentative sample.

Marshall et al. (1980) followed Dahlberg's procedure and generated a smooth curve using the stock composition estimates derived by analysis of the scale patterns of one age class. This method assumes that the proportion of Chignik Lake stock in Chignik Lagoon steadily increases (while the proportion of Black Lake stock declines) during the season and deviations from this pattern are not recognized. This assumption is not met because the early arriving Black River spawners belong to the Chignik Lake stock and, in some years, contribute substantially to the early arriving portion of the run. In addition, the smooth curve estimated by Dahlberg's procedure is extremely sensitive to the logarithmic-tranformed proportional estimates and the position and shape of the curve is greatly influenced by the number of significant digits used in its calculation (Parker et al. 1981). Because of these problems, this method was not considered appropriate.

A simple but effective procedure is to weight the adjusted stock composition estimates for an age class equally and smooth them by a moving average of three sample dates. Two benefits of this procedure are: (1) the effects of samples which might not be representative of the actual stock composition in the Lagoon are partly ameliorated; and (2) the variances of the smoothed stock composition estimates were smaller than the variances of the original adjusted estimates. The variance of a smoothed estimate was estimated by

$$var(i) = (1/3)^2 \, [var(i-1) + var(i) + var(i+1)],$$

where i = sample being processed, $i-1$ = the sample preceding i, and $i+1$ = the sample following i. In order to include all samples collected during the period of transition it was assumed any sample collected prior to the first sampling date would consist entirely of Black Lake stock and the first sample used to construct the Chignik Lake standard (after the period of transition) consisted of 100% Chignik Lake spawners. Negative stock composition estimates were set to 0.0 and estimates greater than 1.0 set to 1.0 before the estimates were smoothed. The stock composition on days between sampling dates was estimated by linear interpolation of the smoothed estimates.

Estimating the Daily Age Composition in Chignik Lagoon

Before the age-specific stock composition estimates could be applied, the total daily catch and escapement counts had to be apportioned by age class. The age composition of the scale samples collected in Chignik Lagoon was used to describe a daily age composition. For the escapements prior to the first Lagoon sampling date, the age composition of the first sample collected was used. The age composition of subsequent samples was applied to the run totals on the day the sample was collected. The age composition for days between two sampling dates was estimated by linear interpolation between estimates from the two samples. The age composition of the last Lagoon sample was applied to the total catch and escapement on that day and on succeeding days.

Using the age composition of samples collected in Chignik Lagoon to estimate the age composition of the escapements involves the assumption that the commercial purse seine fishery in the Lagoon randomly samples all age groups. Roos (1960b) and Dahlberg (1968) both state that the age composition of samples collected at Chignik weir is comparable to the age composition observed in Chignik Lagoon.

Separating the Total Catch and Escapement by Stock

Estimating the number and age composition of each stock in the total daily catch and daily escapement was then a simple procedure. The number in each age class was estimated by applying the age composition estimated for a day to the number in the total catch or the escapement for that day (adjusted to Lagoon date). The number of each stock in an age class was then determined by applying the smoothed stock composition estimate for an age class to the number in the age class. For age classes for which there were not stock composition estimates, the average of the estimates available was applied. This procedure was followed for all days on which there was either an escapement or catch of sockeye salmon. By summing the daily estimates of the number of each stock present by age class, the total number and age composition of the Black Lake and Chignik Lake stocks in the total catch and escapement was estimated.

METHODS FOR IN-SEASON ANALYSES

In-season estimates of the number of each stock in the daily escapement are required so that the cumulative escapement of each stock can be monitored throughout the season. Cumulative escapement goals for each stock are established for each week of the run to ensure optimum escapements to the Black Lake and Chignik Lake spawning grounds. The management strategy is to regulate the commercial fishery according to the status of the cumulative escapement of each stock relative to its weekly goal. If the cumulative escapement of a stock (or both stocks) is considerably below the weekly goal the fishery is closed or remains closed. If the cumulative escapements exceed the weekly goals the fishery is opened or remains open.

The basic procedure used to perform a post-season analysis was applied to the in-season analysis. Scale samples collected in Chignik Lagoon were used to estimate the stock and age composition of the run. Daily estimates of the stock and age composition of the run were calculated following a procedure similar to the post-season analysis. The daily estimates were then applied to the total daily escapement after allowing for a one-day migration time from the Lagoon to the weir. The number of each stock in the escapement was estimated and cumulative totals were kept. The major difference between a post-season and an in-season analysis was the construction of the standards necessary to compute the age-specific LDFs.

Constructing the Standards for an In-season LDF Analysis

The Black Lake standards for an in-season analysis can be constructed from the scale samples collected at the outlet of Black Lake during the season. Because the early portion of the run consists primarily of Black Lake spawners, sufficient numbers of scales for the necessary Black Lake standards can be collected before the critical period of transition from Black Lake to Chignik Lake stock. An initial standard can be established and used for a preliminary analysis. As more samples are collected later in the season the standard can be enlarged for later analyses.

Unfortunately, the Chignik Lake in-season standards could not be established in a similar manner. Standards to perform the LDF analyses were required well before any samples collected in Chignik Lagoon could be used to construct the Chignik Lake standards. Therefore, it was necessary to construct "artificial" standards which were representative of the Chignik Lake spawners for the age classes being analyzed. Two possibilities examined for constructing "artificial" Chignik Lake standards were: (1) using scales from Chignik Lake spawners of the same lacustrine age and from the same brood year but which returned one year prior to the year of analysis, for example using the 1981 2.2 Chignik Lake standard to represent the 1982 2.3 standard; and (2) pooling the standards for one age class over a number of years to establish a universal standard which is representative of the Chignik Lake spawners of an age class in any year.

The lacustrine scale patterns of one year's 2.2 Chignik Lake return should be similar to the following year's 2.3 Chignik Lake return. These fish, from the same brood year, would have reared in the lake during the same time period, and would have experienced the same environmental conditions during their lacustrine life. Clutter and Whitesel (1956) compared the lacustrine scale patterns of age 1.1 sockeye salmon jacks from different Fraser River stocks to those of age 1.2 adults returning one year later. They found that the scale patterns were similar, but the jacks generally had more lacustrine circuli. Henry (1961) used age 1.1 sockeye salmon jacks from the major Fraser River stocks to establish his criteria from separating the age 1.2 adult return in the next year by stock. He found that the lacustrine circuli counts of the jacks were very similar to the counts of the 1.2 adults from the same stock in the following year.

A 1.3 Chignik Lake standard for in-season analyses cannot be established using the previous year's 1.2 return to Chignik Lake, however, because the 1.2 age class is never present in sufficient numbers in the Chignik Lake stock to provide an adequate standard. This method could only be used for an in-season analysis of the 2.3 age class.

The Hotelling T^2 statistic, used to test the equality of scale characters between males and female, was also used to compare the scale patterns of one year's 2.3 Chignik Lake adults and the previous year's 2.2 Chignik Lake adults. The same subsets of basic scale growth characters used to ompare the sexes were used in this analysis. They were, in the first lacustrine annular zone; the mean width of and mean number of circuli in the zone and the mean distance from the center of the scale focus to each of the first five circuli in the zone; and in the second lacustrine annular zone; the mean width of and mean number of circuli in the zone and the mean distance from the end of the first lacustrine annulus to each of the first five circuli in the zone. As in the comparison of the sexes, separate tests were performed for the characters in each annular zone, and scales having less than five circuli in an annular zone were omitted from the analysis.

Four sets of Chignik Lake 2.2-2.3 scale measurement data were tested. They were: (1) the 1978 2.2 - 1979 2.3; (2) the 1979 2.2 - 1980 2.3; (3) 1980 - 2.2 - 1981 2.3; and (4) the 1981 2.2 - 1982 2.3. If a significant difference were found for a 2.2-2.3 comparison, Roy-Bose 95.0% simultaneous confidence intervals were constructed to determine which variables were responsible for the difference.

Multivariate analysis of variance (MANOVA) was used to test the hypothesis that, for the Chignik Lake stock, scale growth for an age class does not vary significantly from year to year. If this hypothesis were not rejected, a universal Chignik Lake standard could be established for each of the major age classes by pooling the scale measurement data for an age class over a number of years. A MANOVA tests the equality of group mean vectors for two or more groups (Cooley and Lohnes 1971). The Hotelling T^2 statistic, described previously, is a special case of MANOVA when only two groups are being tested. The major assumptions for MANOVA are identical to those for the Hotelling T^2 test.

SPSS MANOVA (Hull and Nie 1981) was used to compare the vectors of mean scale growth characters of the 1.3 and 2.3 age classes for the Chignik Lake standards from the years 1978-1982. The same subset of scale characters in each lacustrine annular zone used in the previous analyses comparing scale growth were used for this analysis. As was done previously, a separate analysis was performed for the scale characters in each lacustrine annular zone.

Selection of Scale Characters for In-season LDF Analysis

The procedure used to select a "best" set of scale characters to use in an in-season LDF analysis of an age class depended on the standard selected to represent the actual Chignik Lake standard. If a year's pooled standard was used, the stepwise F procedure for the post-season analysis was used and all scale characters were screened. For one age class, the difference in scale growth during the years 1978-1982 were assumed to be smaller than the differences in scale growth between the Black Lake and Chignik Lake stocks for those years. The set of scale characters which best separated the Black Lake stock from the year's pooled standard would also be the set which best separated the Black Lake and Chignik Lake stocks.

If a 2.2 Chignik Lake standard was used to represent the next year's 2.3 Chignik Lake standard, a modified set of scale character variables was considered. Those variables which best discriminated between the 2.2 Chignik Lake standard and the 2.3 Black Lake standard might include variables which were significantly different between the 2.2 Chignik Lake standard and the 2.3 standard it represented. The scale characters screened for the in-season analysis were those which were not significantly different between the 2.2-2.3 Chignik Lake standard but still provided discrimination between the Black Lake and Chignik Lake stocks.

The four sets of 2.2-2.3 Chignik Lake standards were compared by the pairwise F tests used for the initial screening of the scale characters in the post-season analyses. All scale characters for which there were no significant differences between the 2.2-2.3 standards in any of the years considered were screened for the in-season LDF analyses. An effective set of scale characters for discriminating between the Black Lake and Chignik Lake stocks was selected from this subset with the stepwise F test.

Separating the Escapement by Stock

Once an LDF for each class being analyzed for the in-season analysis had been defined using the Black Lake standard and the representative Chignik Lake standard, the number of each stock in the escapement was estimated. The same procedure used for the post-season analyses were followed with one modification. For the in-season analyses, it was important to have estimates of the cumulative escapement of each stock which included the most recent escapements. After the stock composition estimates derived in-season were smoothed, daily stock composition estimates could be interpolated only for the days up to the sample preceding the most recent one. Stock composition estimates for the period between the last sample and the sample preceding it were derived by weighting the most recent stock composition estimate twice and applying the smoothing procedure. Stock composition estimates were then available for the days up to and including the day of the most recent sample. The cumulative escapement of each stock was estimated by summing the estimates. The cumulative totals were updated on each subsequent sample date.

RESULTS

Consistency in Age Interpretation of Scales

Three large scale samples were re-aged approximately one year after the initial reading. The number of scales assigned an age different from the initial interpretation were: for the 1978 Black Lake samples, the ages of 30 scales of the 1,595 scales aged were changed (1.9%); for the 1980 Black Lake samples, the ages of 27 scales of the 1,367 scales aged were changed (2.0%); and for the 1980 samples collected in Chignik Lagoon during July, the ages of 58 of the 1,853 scales aged were changed (3.1%). The high rate of agreement between the first and second age readings (97.6% for all samples re-aged) indicates a consistent interpretation of the annuli on the scales throughout the study. A comparison of the age composition determined for each sample by the first and second readings is given in Table 4. Because many of the age changes were reciprocal, the difference between the number of scales assigned to each age group for the first and second readings is less than the total number of scales assigned new ages for a sample.

Comparison of Scale Growth Between Males and Females

The results of the test of the hypothesis that, within an age class and brood years, male and female sockeye salmon from the same stock have identical mean scale growth vectors, are given for the first lacustrine annular zone and the second lacustrine annular zone in Tables 5 and 6, respectively, for each standard tested. The significance of the multivariate test using the Hotelling T^2 statistic is indicated for each test performed. When the hypothesis of identical scale growth was rejected, the scale characters responsible for the difference, as indicated by Roy-Bose 95.0% simultaneous confidence intervals, are listed. The result of Box's test of the hypothesis of equal covariance matrices for males and females, an assumption necessary for the Hotelling T^2 test, is given for each analysis, also.

Significant differences between the mean scale growth of males and females were found in only two instances. The mean scale growth vectors for the first lacustrine annular zone were found to be significantly different (α = 0.05) in both the 1981 1.3 Chignik Lake standard and the 1979 2.2 Black Lake standard. In both cases, the mean number of circuli in the first lacustrine annular zone was the character responsible for the difference. No significant differences were found between male and female mean scale growth in the second lacustrine annular zone. Because of the low rate of rejection of the hypothesis of identical scale growth, 7.7% (2/26) of the tests in the first lacustrine annular zone and 0.0% (0/17) of the tests in the second lacustrine annular zone, it seems safe to conclude that there were significant differences between the scale growth of males and females. This allowed both sexes to be included in the standards necessary to separate the Chignik stocks by their scale patterns with LDF analysis.

The hypothesis of equal covariance matrices for males and females was rejected in only 5 of the 43 tests performed. For most of the tests performed the assumption of equal covariance matrices was met. This indicates that the data was approximately linear and the Hottelling T^2 test was appropriate for testing the equality of the mean scale character vectors.

Table 4. Comparison of the age compositions for the first and second readings of the scale samples.

Reading		Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
1978 Black Lake samples													
1	Number	0	0	36	62	0	1,182	314	0	1	0	0	1,595
	Percentage	0.0	0.0	2.2	3.9	0.0	74.1	19.7	0.0	0.1	0.0	0.0	100.0
2	Number	0	0	35	63	0	1,163	333	0	1	0	0	1,595
	Percentage	0.0	0.0	2.2	3.9	0.0	72.9	20.9	0.0	0.1	0.0	0.0	100.0
1980 Black Lake samples													
1	Number	2	0	250	36	0	509	556	0	1	0	13	1,367
	Percentage	0.1	0.0	18.3	2.6	0.0	37.2	40.7	0.0	0.1	0.0	1.0	100.0
2	Number	2	0	248	38	0	502	563	0	1	0	13	1,367
	Percentage	0.1	0.0	18.1	2.8	0.0	36.7	41.2	0.0	0.1	0.0	1.0	100.0
1980 Chignik Lagoon samples (7/5-7/19)													
1	Number	1	1	82	341	2	138	1,269	12	0	3	4	1,853
	Percentage	0.1	0.1	4.4	18.4	0.1	7.4	68.5	0.6	0.0	0.2	0.2	100.0
2	Number	1	1	88	334	3	143	1,264	12	0	3	4	1,853
	Percentage	0.1	0.1	4.7	18.0	0.2	7.7	68.2	0.6	0.0	0.2	0.2	100.0

Table 5. Results of Hotelling's test for the equality of the mean scale growth vectors of the first lacustrine annular zone for males and females. The results of Box's test for the equality of variance-covariance matrices are reported, also. (NS = not significant, SIGN = significant $\alpha \leq 0.05$)

Standard		Age	Sample size		Box's test	Hotelling's test	Significant characters
			Males	Females			
1978	BL	2.2	44	11	NS	NS	
	CL	2.2	39	50	NS	NS	
1979	BL	2.2	63	36	NS	SIGN	number circuli
	CL	2.2	28	28	NS	NS	
1980	BL	2.2	19	17	NS	NS	
	CL	2.2	59	81	NS	NS	
1981	CL	2.2	56	90	NS	NS	
1978	BL	1.3	104	96	NS	NS	
	CL	1.3	12	15	NS	NS	
1979	BL	1.3	76	124	SIGN	NS	
1980	BL	1.3	58	142	NS	NS	
	CL	1.3	9	16	NS	NS	
1981	BL	1.3	81	119	NS	NS	
	CL	1.3	46	77	NS	SIGN	number circuli
1982	BL	1.3	22	45	NS	NS	
	CL	1.3	87	113	NS	NS	
1978	BL	2.3	105	94	NS	NS	
	CL	2.3	76	90	SIGN	NS	
1979	BL	2.3	82	115	NS	NS	
	CL	2.3	10	12	NS	NS	
1980	BL	2.3	66	134	NS	NS	
	CL	2.3	79	121	NS	NS	
1981	BL	2.3	60	71	NS	NS	
	CL	2.3	75	113	NS	NS	
1982	BL	2.3	49	37	NS	NS	
	CL	2.3	83	112	NS	NS	

BL = Black Lake, CL = Chignik Lake

Table 6. Results of Hotelling's test for the equality of the mean scale growth vectors of the second lacustrine annular zone for males and females. The results of Box's test for the equality of covariance matrices are reported, also. (NS = not significant, SIGN = significant $\alpha \leq 0.05$)

Standard		Age	Sample size Males	Females	Box's test	Hotelling's test	Significant characters
1978	BL	2.2	44	11	NS	NS	
	CL	2.2	54	73	NS	NS	
1979	BL	2.2	63	36	NS	NS	
	CL	2.2	30	29	NS	NS	
1980	BL	2.2	19	17	NS	NS	
	CL	2.2	63	86	NS	NS	
1981	CL	2.2	61	98	NS	NS	
1978	BL	2.3	104	93	NS	NS	
	CL	2.3	87	112	NS	NS	
1979	BL	2.3	84	116	NS	NS	
	CL	2.3	38	46	NS	NS	
1980	BL	2.3	66	134	SIGN	NS	
	CL	2.3	79	121	NS	NS	
1981	BL	2.3	53	65	SIGN	NS	
	CL	2.3	72	119	NS	NS	
1982	BL	2.3	58	44	SIGN	NS	
	CL	2.3	87	113	NS	NS	

BL = Black Lake, CL = Chignik Lake

Post-season Separation by Stock of the Chignik Sockeye Salmon Runs, 1978-1982

The results of the post-season stock separation analyses of the Chignik sockeye salmon runs by scale patterns and linear discriminant function analysis are summarized for each of the years 1978-1982 in the following section. The intermediate results of the procedure for estimating the total number and age composition of each stock in the catch and escapement are presented. This includes estimates of the total daily abundance throughout the run, the age composition of scale samples collected in Chignik Lagoon, the discriminant functions determined for each of the major age classes in the run, and the stock composition estimates for each age class for the samples of unknown composition collected in Chignik Lagoon. Final estimates of the total number of each stock in the catch and escapement and the age composition of each of these components are given.

1978:

The total sockeye salmon run to Chignik in 1978 was 2,503,600 and was composed of an escapement of 682,547 and total catch of 1,821,053 (Appendix Table 3a). There were two periods of peak abundance in the 1978 sockeye salmon run, one during the second week of June and one in the middle of July (Figure 8). The peak daily abundance was on 19 July when the combined catch and escapement was 225,535 fish.

Scale samples were collected in Chignik Lagoon on 19 separate occasions from 9 June to 23 August (Appendix Table 3b). The sampling effort was evenly distributed throughout the period of high daily abundance, from about 7 June to 27 July. Ages were assigned to 2,259 (83.9%) of the 2,692 scales collected in Chignik Lagoon. The remaining scales were omitted from the analysis because of regeneration of the nuclear area or a poor impression in the acetate. The change in the relative abundance of the major age classes present in Chignik Lagoon during 1978 is typical of the Chignik sockeye salmon run (Figure 9). The 1.3 age class was most abundant in early June and declined rapidly after 17 June. During the period of decline in abundance of the 1.3 age class there was a corresponding increase in abundance of the 2.3 age class. There was a rapid increase in the relative abundance of the 2.2 age class in late July and early August.

Scale samples necessary to construct the Black Lake standards for the LDF analyses were collected at the outlet of Black Lake on 10 separate days during June and early July (Appendix Table 3c). A total of 1,860 scales were collected, of which 1,595 (85.8%) could be aged. The 1.3 age class was the most abundant in the Black Lake samples with approximately 70% of the scales collected assigned to it.

Black Lake and Chignik Lake standards were established for the 2.2, 1.3, and 2.3 age classes in the 1978 run. Classification accuracies of the linear discriminant funtions for ages 2.2, 1.3, and 2.3 sockeye salmon were 92.4%, 76.5%, and 89.8%, respectively (Table 7). The scale characters selected for each LDF for an age class, and the mean and standard deviation for each character by stock, are presented in Table 8.

The 1.3 and 2.3 age classes were present in numbers sufficient for analysis of their scale patterns for the scale samples collected in Chignik Lagoon during 1978.

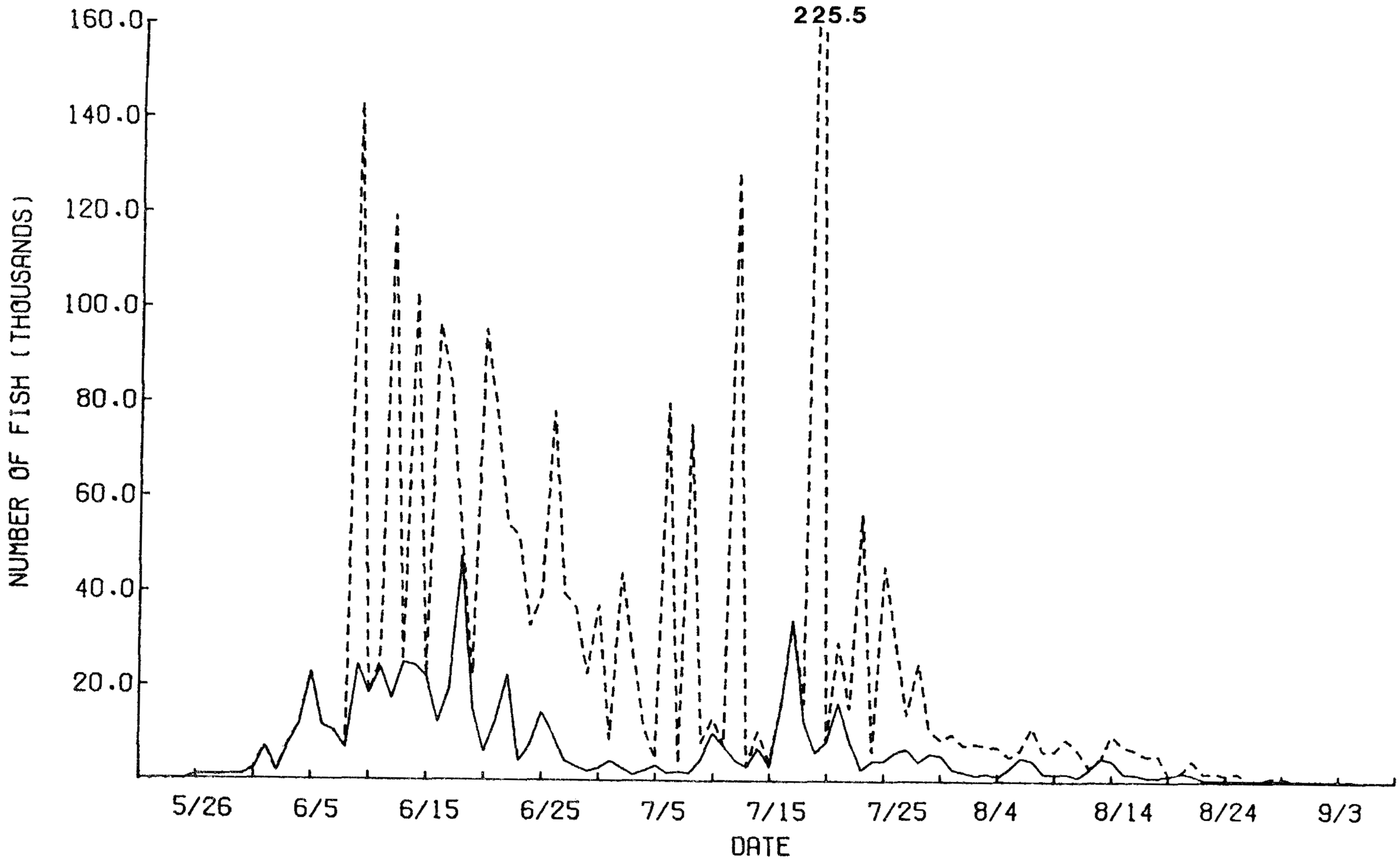

Figure 8. Daily escapement (——) and total daily abundance (---), adjusted to Chignik Lagoon date, for the 1978 Chignik sockeye salmon run.

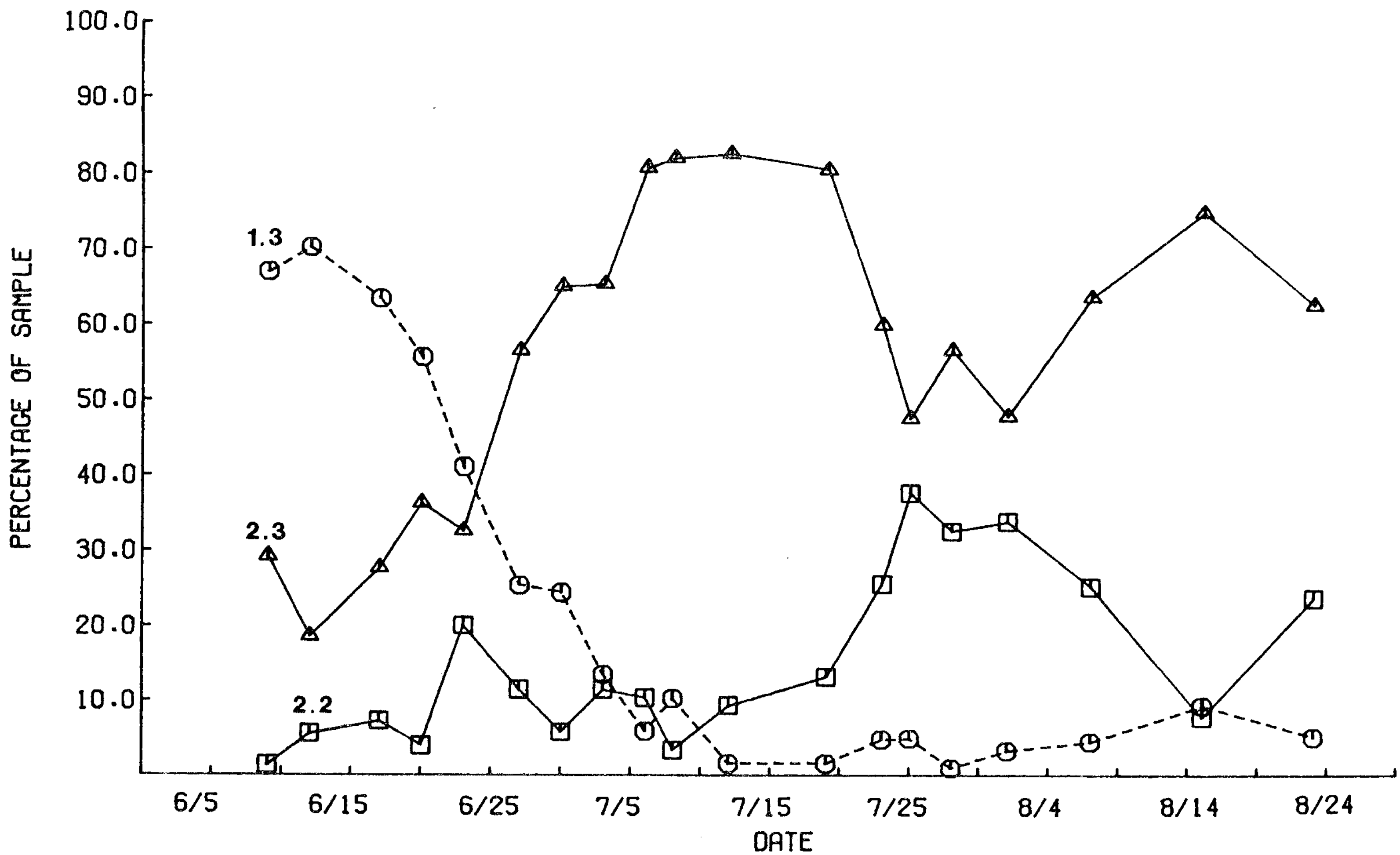

Figure 9. Age composition of scale samples collected in Chignik Lagoon during the 1978 sockeye salmon run, by sample date. Minor age groups are not shown.

Table 7. Classification matrices for age 2.2, 1.3, and 2.3 sockeye salmon in the 1978 Chignik run.

Age 2.2

Classified stock of origin	Actual stock of origin: Black Lake	Actual stock of origin: Chignik Lake
Black Lake	0.909	0.062
Chignik Lake	0.091	0.938
Sample size	55	129

Mean classification = 0.924

Age 1.3

Classified stock of origin	Actual stock of origin: Black Lake	Actual stock of origin: Chignik Lake
Black Lake	0.850	0.321
Chignik Lake	0.150	0.679
Sample size	200	28

Mean classification = 0.765

Age 2.3

Classified stock of origin	Actual stock of origin: Black Lake	Actual stock of origin: Chignik Lake
Black Lake	0.875	0.080
Chignik Lake	0.125	0.920
Sample size	200	200

Mean classification = 0.898

Table 8. Scale characters selected for the final discriminant functions used to classify the 2.2, 1.3, and 2.3 age classes in the 1978 Chignik sockeye salmon run. (C = circulus, FW = freshwater, AZ = annular zone).

Age 2.2

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. distance C1 (1st FW AZ) to end of 1st FW AZ	89.3	17.4	59.8	14.8
2. width of 2nd FW AZ	114.0	17.5	103.8	16.2
3. total width of FW growth zone	263.2	24.6	210.7	23.8
Sample size	55		129	

Equality of covariance matrices, significant $\alpha \leq 0.01$

Age 1.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. distance focus to C3, 1st FW AZ	116.6	10.6	98.1	19.4
2. 1st C widest pair in 1st FW AZ	1.7	0.8	2.5	1.6
3. distance C1 to C4, 1st FW AZ	78.3	10.5	62.7	14.9
Sample size	200		28	

Equality of covariance matrices, significant $\alpha \leq 0.01$

Age 2.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. width of 1st FW AZ	165.8	24.2	113.4	17.6
2. number of circuli in 2nd FW AZ	6.1	0.8	6.0	0.7
3. distance C1 (1st FW AZ) to end of 1st FW AZ	107.9	22.4	65.5	14.6
4. average interval between circuli in the 1st FW AZ	26.1	3.2	22.2	2.4
Sample size	200		200	

Equality of covariance matrices, significant $\alpha \leq 0.01$

After 30 June, the analysis of the 1.3 age class could not continue because of insufficient sample sizes. The adjusted stock composition estimates and the smoothed stock composition estimates, and their estimated variances, for the Chignik Lagoon samples analyzed are presented for each age class in Tables 9 and 10. A comparison of the smoothed daily stock composition estimates for the 1.3 and 2.3 age classes and the TOE curve used by ADF&G to separate the run by stock in 1978 is shown in Figure 10.

The total Black Lake run in 1978 was 1,526,604 sockeye salmon, with an escapement of 458,660 and total catch of 1,067,944 (Table 11). The 1.3 and 2.3 age classes were nearly equally abundant in the run accounting for 49.3% and 38.5% of the total run, respectively. The total Chignik Lake run was 976,996. The escapement to Chignik Lake spawning areas was 223,887 fish and there were 753,109 Chignik Lake fish taken in the commercial catch (Table 11). Approximately 70% of the total Chignik Lake run was assigned to the 2.3 age class. The Black Lake stock was most abundant during June, from about 1 July to 3 July both stocks were equally abundant, and after this the Chignik Lake stock increased in abundance (Figure 11, Appendix Tables 3d and 3e). This pattern of abundance by stock is typical of the Chignik sockeye salmon run.

1979:

The total sockeye salmon run to Chignik in 1979 was 1,801,845. There were 737,816 salmon in the escapement and a total catch of 1,064,029 (Appendix Table 4a). The early-arriving portion of the run was not abundant with only one day in June having a total abundance greater than 50,000 (Figure 12). There was a much larger peak in abundance during the second week of July when the total daily abundance approached 100,000 on two separate days.

Scale samples were collected in Chignik Lagoon on 17 sample dates between 6 June and 31 August (Appendix Table 4b). Only four samples were collected in the Lagoon during June, which was less often than desired. Sampling was evenly distributed throughout the period of high daily abundance in July. Of the 6,728 scales collected, 5,380 (80.0%) were sufficiently legible to age. Age 2.3 sockeye salmon were the most abundant age group in every sample collected in Chignik Lagoon (Figure 13). Two peaks in the relative abundance of the 2.2 age class were evident, one in late June and the other in late July.

Scale samples for the Black Lake standards were collected at Black Lake outlet on five occasions between 19 June and 28 June (Appendix Table 4c). The small escapement to Black Lake in 1979 required that all samples be collected during this short period and not distributed over a longer period of time. A total of 1,568 scales were collected and ages were assigned to 1,397 (89.1%). The 2.3 age class was more abundant than the 1.3 age class in all the samples collected, which is very unusual for Black Lake samples. The 1.3 age class, which is usually the most abundant age class in the Black Lake stock, only accounted for about 30% of the Black Lake scales collected while the 2.3 age class accounted for more than 50%.

Standards for the Black Lake and Chignik Lake stocks were established for the 2.2, 1.3, and 2.3 age classes in the 1979 run. Classification accuracies for the

Table 9. Stock composition estimates for the scale pattern analysis of the 1.3 age class in the 1978 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 9	100	Black Lake	1.019	.00668	1.000	.00155
		Chignik Lake	-.019	.00668	0.000	.00155
6/12	73	Black Lake	1.102	.00730	1.000	.00248
		Chignik Lake	-.102	.00730	0.000	.00248
6/17	72	Black Lake	1.021	.00832	1.000	.00279
		Chignik Lake	-.021	.00832	0.000	.00279
6/20	62	Black Lake	1.009	.00947	1.000	.00311
		Chignik Lake	-.009	.00947	0.000	.00311
6/23	50	Black Lake	1.057	.01018	.949	.00515
		Chignik Lake	-.057	.01018	.051	.00515
6/27	26	Black Lake	.847	.02668	.949	.00667
		Chignik Lake	.153	.02668	.051	.00667
6/30	21	Black Lake	1.014	.02318		
		Chignik Lake	-.014	.02318		

Table 10. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1978 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 9	50	Black Lake	.981	.00464	.955	.00189
		Chignik Lake	.019	.00464	.045	.00189
6/12	23	Black Lake	.884	.01239	.929	.00281
		Chignik Lake	.116	.01239	.071	.00281
6/17	32	Black Lake	.921	.00827	.935	.00270
		Chignik Lake	.079	.00827	.065	.00270
6/20	41	Black Lake	1.065	.00360	.879	.00237
		Chignik Lake	-.065	.00360	.121	.00237
6/23	40	Black Lake	.717	.00949	.787	.00215
		Chignik Lake	.283	.00949	.213	.00215
6/27	66	Black Lake	.643	.00623	.685	.00263
		Chignik Lake	.357	.00623	.315	.00263
6/30	49	Black Lake	.695	.00798	.550	.00229
		Chignik Lake	.305	.00798	.450	.00229
7/ 3	58	Black Lake	.311	.00637	.469	.00206
		Chignik Lake	.689	.00637	.531	.00206
7/ 6	98	Black Lake	.400	.00422	.362	.00172
		Chignik Lake	.600	.00422	.638	.00172
7/ 8	82	Black Lake	.375	.00489	.361	.00149
		Chignik Lake	.625	.00489	.639	.00149
7/12	89	Black Lake	.309	.00427	.341	.00154
		Chignik Lake	.691	.00427	.659	.00154
7/19	83	Black Lake	.339	.00469	.286	.00157
		Chignik Lake	.661	.00469	.714	.00157
7/23	61	Black Lake	.209	.00521	.183	.00110
		Chignik Lake	.791	.00521	.817	.00110

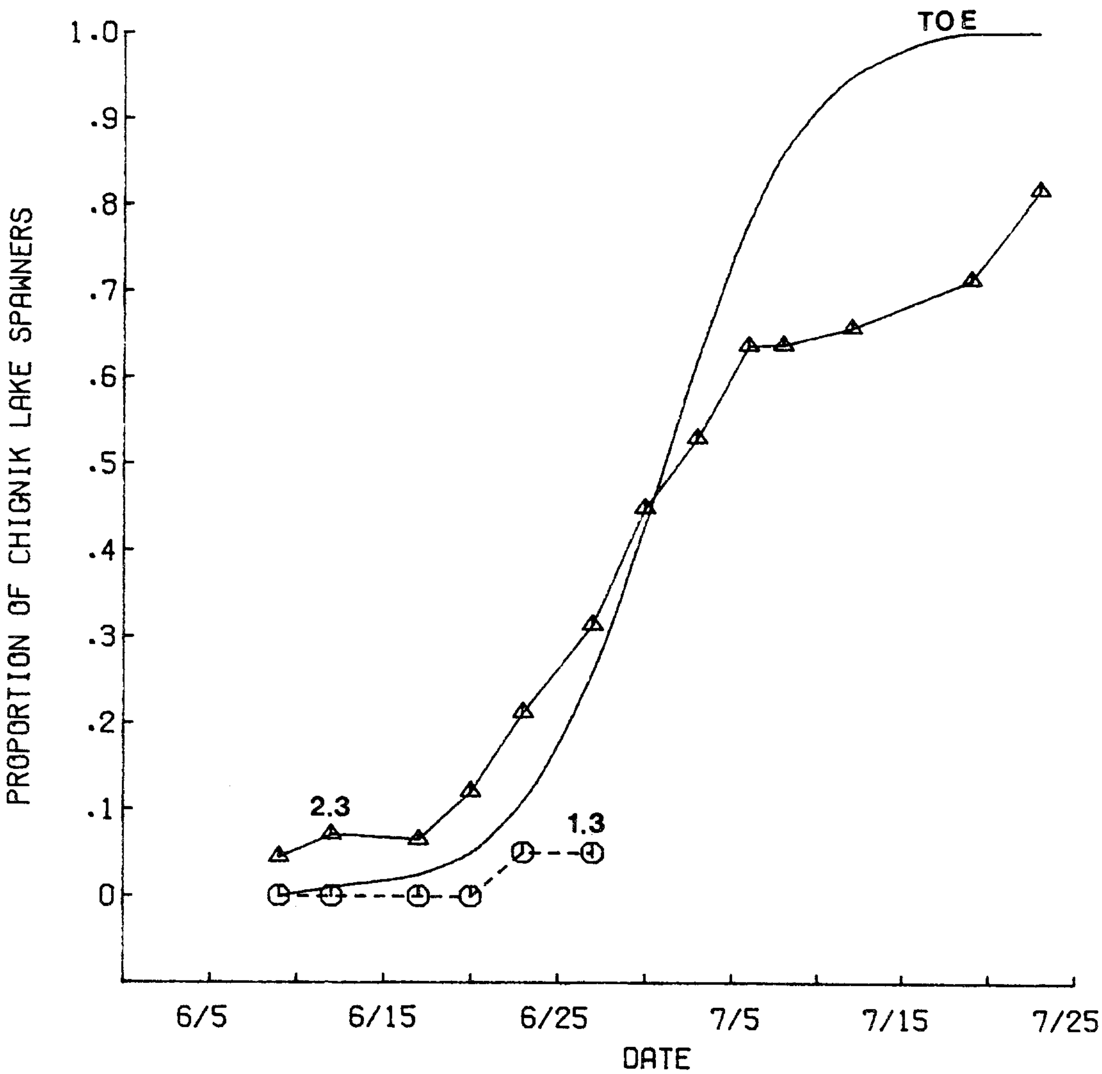

Figure 10. Daily stock composition during the period of transition for the age-specific stock composition estimates smoothed by a moving average of three sample dates. The average TOE curve (shifted five days earlier) used by ADF&G to separate the 1978 Chignik sockeye salmon run by stock is shown for comparison.

Table 11. Summary of the escapement, commercial catch, and total return by age class and stock for the 1978 Chignik sockeye salmon run estimated by analysis of scale patterns.

	Age											Total
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	
Black Lake												
Escapement	0	34	13,754	30,076	1,065	258,886	152,316	1,177	1,316	36	0	458,660
%	0.00	0.01	3.00	6.56	0.23	56.44	33.21	0.25	0.29	0.01	0.00	100.00
Catch	0	299	36,959	90,953	3,523	493,830	434,703	5,575	1,874	228	0	1,067,944
%	0.00	0.03	3.46	8.52	0.33	46.24	40.70	0.52	0.18	0.02	0.00	100.00
Total	0	333	50,713	121,029	4,588	752,716	587,019	6,752	3,190	264	0	1,526,604
%	0.00	0.02	3.32	7.93	0.30	49.31	38.45	0.44	0.21	0.02	0.00	100.00
Chignik Lake												
Escapement	0	705	4,056	40,739	7,514	10,214	156,737	3,012	35	875	0	223,887
%	0.00	0.31	1.81	18.20	3.36	4.56	70.01	1.34	0.02	0.39	0.00	100.00
Catch	0	1,948	14,453	125,334	22,028	44,241	532,876	10,317	59	1,853	0	753,109
%	0.00	0.26	1.92	16.64	2.92	5.87	70.76	1.37	0.01	0.25	0.00	100.00
Total	0	2,653	18,509	166,073	29,542	54,455	689,613	13,329	94	2,728	0	976,996
%	0.00	0.27	1.90	17.00	3.02	5.57	70.59	1.36	0.01	0.28	0.00	100.00

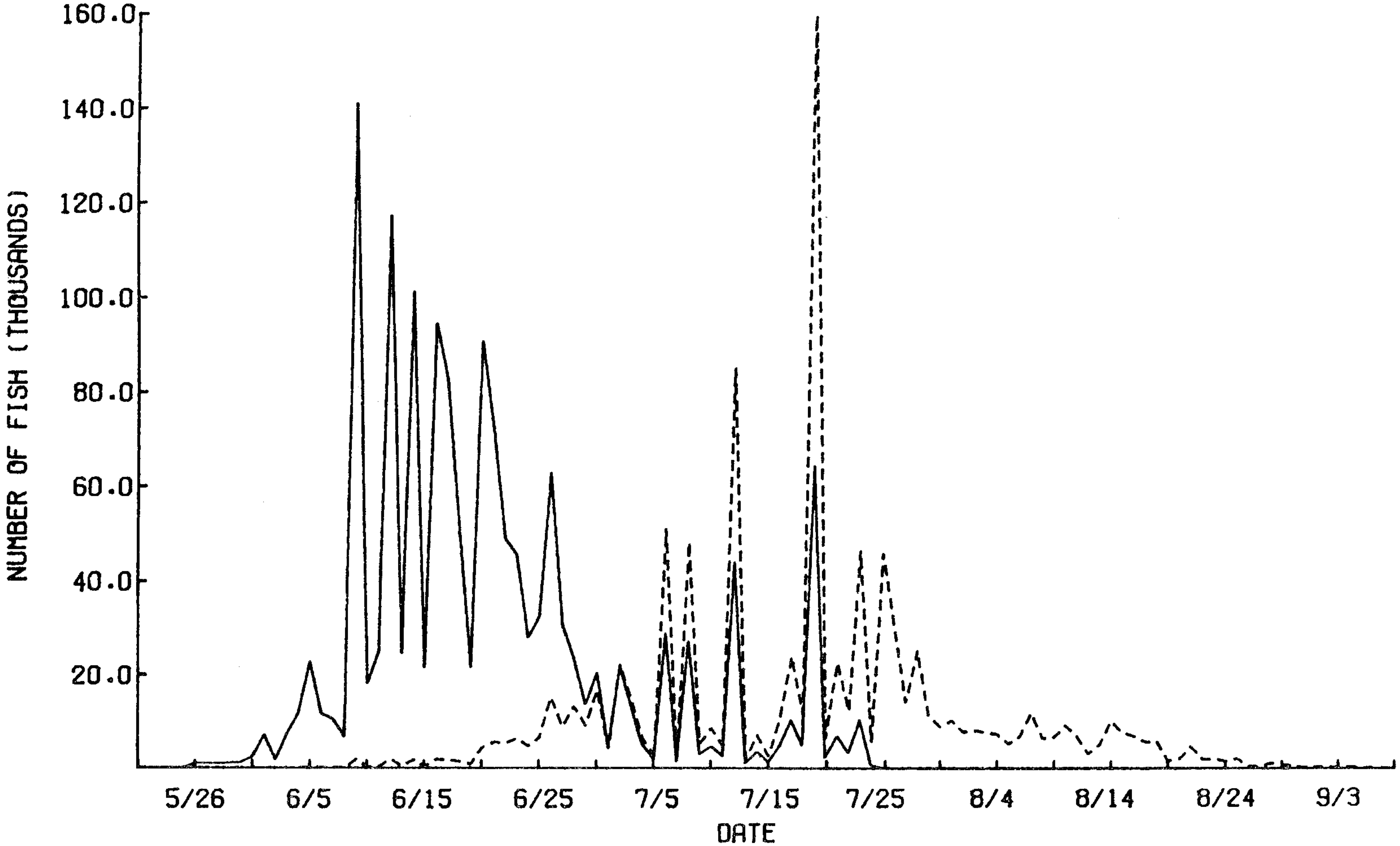

Figure 11. Total daily abundance of the Black Lake (——) and Chignik Lake (---) stocks in the 1978 Chignik sockeye salmon run.

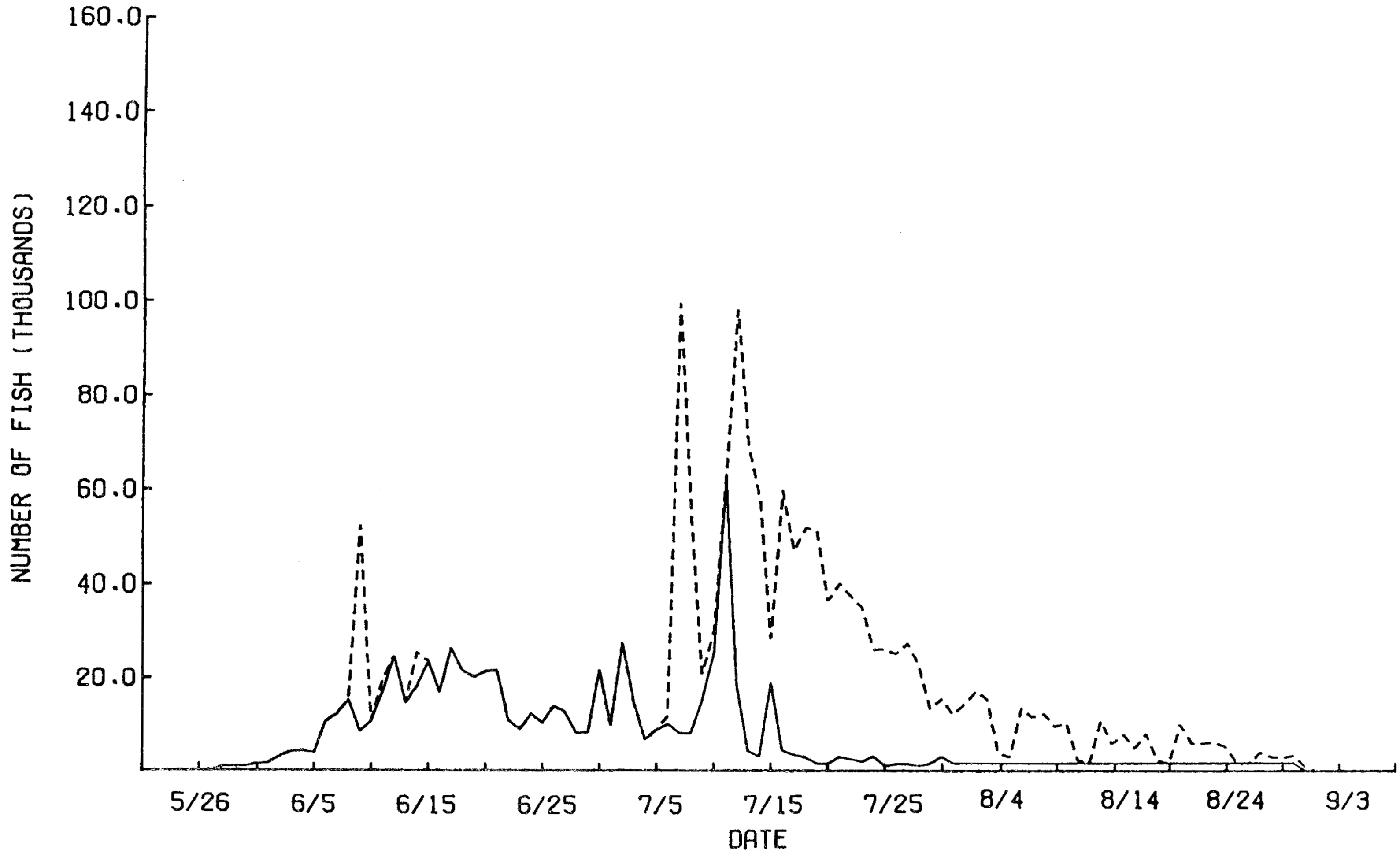

Figure 12. Daily escapement (——) and total daily abundance (---), adjusted to Chignik Lagoon date, for the 1979 Chignik sockeye salmon run.

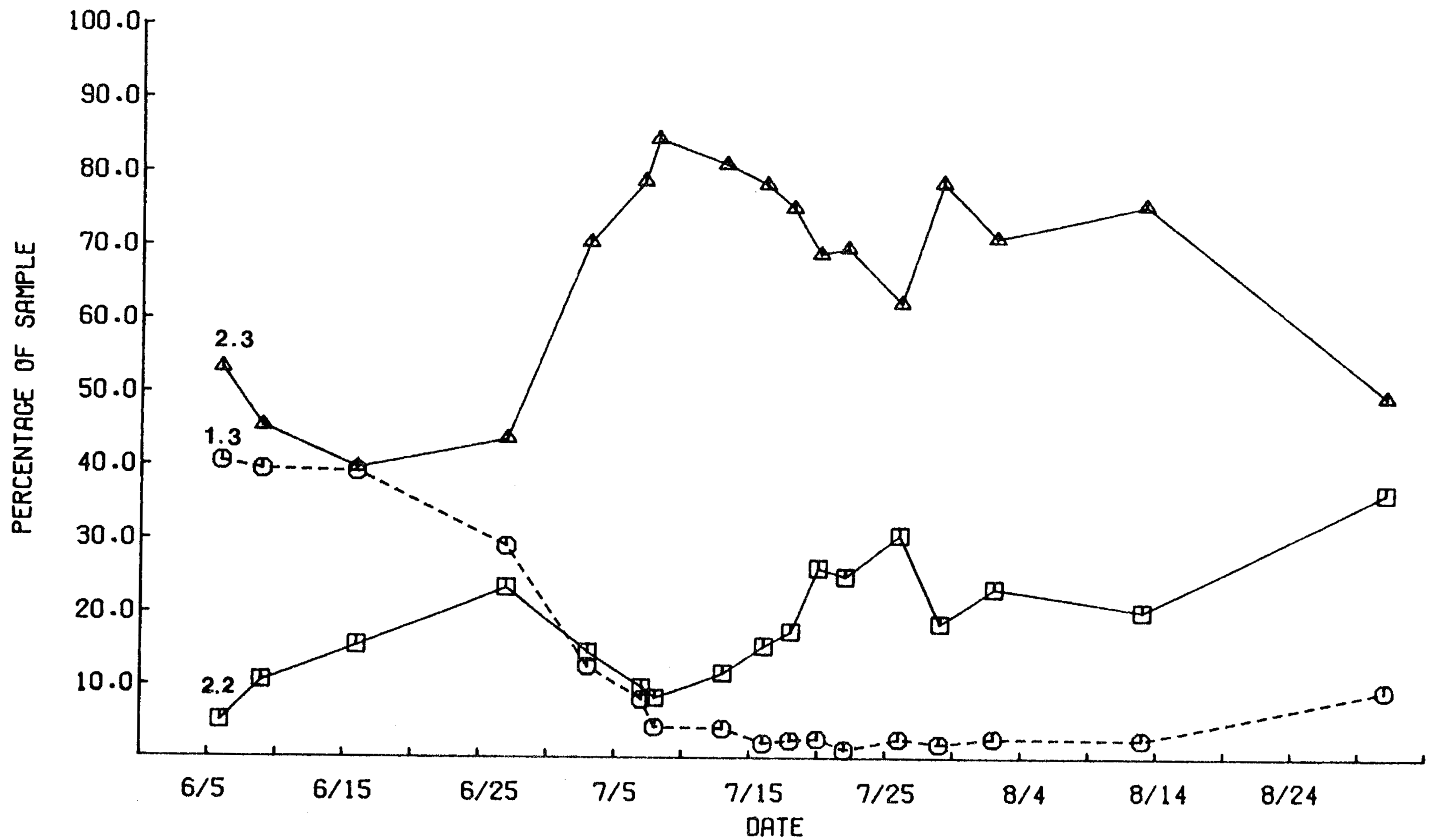

Figure 13. Age composition of scale samples collected in Chignik Lagoon during the 1979 sockeye salmon run, by sample date. Minor age groups are not shown.

linear discriminant functions were 78.4%, 72.6%, and 93.5% for the 2.2, 1.3, and 2.3 age classes, respectively (Table 12). A summary of the scale characters selected for each age-specific LDF is given in Table 13.

The 2.2, 1.3, and 2.3 age classes were present in numbers sufficient for analysis of their scale patterns for the scale samples of unknown stock composition collected in Chignik Lagoon during 1979. The 1.3 age class could not be analyzed after 13 July because of insufficient sample sizes. Tables 14-16 summarize the adjusted stock composition estimates and the smoothed stock composition estimates for the 2.2, 1.3, and 2.3 age classes. A comparison of the smoothed daily stock composition estimates for each age class and the average TOE curve used by ADF&G in 1979 is shown in Figure 14.

The total Black Lake run in 1979 was 576,985, with 385,694 salmon escaping to Black Lake spawning areas and 191,291 taken in the commercial catch (Table 17). More than 50% of the Black Lake run belonged to the 2.3 age class, while age 1.3 and 2.2 salmon were nearly equally abundant. A total of 1,224,860 sockeye salmon were assigned to the Chignik Lake stock. The escapement to Chignik Lake spawning areas was 352,122 and there were 872,738 fish belonging to that stock taken in the catch (Table 17). More than 70% of the Chignik Lake run was assigned to the 2.3 age class. The total daily return by stock is shown in Figure 15. The Black Lake stock was more abundant during June and the Chignik Lake stock was the most abundant stock during July. From about 1 July to 4 July the stocks were equally abundant (Appendix Tables 4d and 4e).

1980:

The total sockeye salmon run to Chignik in 1980 was 1,524,476. There were 664,061 salmon in the escapement and a total catch of 860,415 (Appendix Table 5a). The temporal distribution of the 1980 run was very similar to the 1979 run. A relatively small peak in abundance in June was followed by a much larger peak in abundance during the second week of July (Figure 16).

Scale samples were collected in Chignik Lagoon on 20 sample dates from 6 June to 27 August (Appendix Table 5b). The sampling effort was evenly distributed throughout June and July. Ages were assigned to 3,937 (83.9%) of the 4,691 scales collected in Chignik Lagoon. Similar to the 1979 run, also, was the relative abundance of the major age classes present in Chignik Lagoon throughout the season. Age 2.3 sockeye salmon were the most abundant age group in all samples collected but one (Figure 17). Typically, the 1.3 age class declined in abundance throughout late June and early July and there was a large increase in the abundance of the 2.2 age class in the second week of July.

The small escapement to Black Lake limited the collection of scale samples at Black Lake outlet to a brief period in late June and early July, much as it had in 1979. Scale samples were collected on six days between 26 June and 3 July (Appendix Table 5c). A total of 1,556 scales were collected for the Black Lake standards of which 1,367 (87.9%) were legible. Atypically, the 1.3 and 2.3 age classes were nearly equally abundant with 36.6% and 40.9% of the scales collected assigned to those age classes, respectively.

Table 12. Classification matrices for age 2.2, 1.3, and 2.3 sockeye salmon in the 1979 Chignik run.

Age 2.2

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.737	0.170
Chignik Lake	0.263	0.830
Sample size	99	200

Mean classification = 0.784

Age 1.3

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.680	0.229
Chignik Lake	0.320	0.771
Sample size	200	35

Mean classification = 0.726

Age 2.3

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.925	0.055
Chignik Lake	0.075	0.945
Sample size	200	200

Mean classification = 0.935

Table 13. Scale characters selected for the final discriminant functions used to classify the 2.2, 1.3, and 2.3 age classes in the 1979 Chignik sockeye salmon run. (C = circulus, FW = freshwater, AZ = annular zone)[1].

Age 2.2

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. number of circuli in 1st FW AZ	7.9	1.6	6.0	0.9
2. relative size, width of the widest pair of circuli in the 2nd FW AZ	0.18	0.03	0.16	0.02
Sample size	99		200	

Equality of covariance matrices, significant $\alpha \leq 0.01$

Age 1.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. total width of FW growth zone	220.6	30.5	195.2	26.8
2. distance C1 to C2, 1st FW AZ	24.2	4.7	20.6	4.4
3. distance 3rd C before end of 1st FW AZ to end of 1st FW AZ	49.3	7.7	46.1	6.8
Sample size	200		35	

Equality of covariance matrices, not significant

Age 2.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. width of 1st FW AZ	150.9	19.7	96.9	17.2
2. relative size, distance C1 (2nd FW AZ) to end of 2nd FW AZ	0.85	0.05	0.81	0.05
3. ratio, width 1st FW AZ to width total FW growth zone	0.54	0.06	0.45	0.07
Sample size	200		200	

Equality of covariance matrices, significant $\alpha \leq 0.01$

[1] All linear distances reported in 0.01's of inches at 210X.

Table 14. Stock composition estimates for the scale pattern analysis of the 2.2 age class in the 1979 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 9	20	Black Lake	.847	.03980		
		Chignik Lake	.153	.03980		
6/16	20	Black Lake	.935	.03799	.868	.01274
		Chignik Lake	.065	.03799	.132	.01274
6/27	22	Black Lake	.823	.03691	.766	.01268
		Chignik Lake	.177	.03691	.234	.01268
7/ 3	21	Black Lake	.540	.03919	.700	.01130
		Chignik Lake	.460	.03919	.300	.01130
7/ 7	34	Black Lake	.738	.02562	.674	.01068
		Chignik Lake	.262	.02562	.326	.01068
7/ 8	27	Black Lake	.745	.03134	.674	.00795
		Chignik Lake	.255	.03134	.326	.00795
7/13	63	Black Lake	.540	.01456	.489	.00623
		Chignik Lake	.460	.01456	.511	.00623
7/16	73	Black Lake	.183	.01014	.324	.00375
		Chignik Lake	.817	.01014	.676	.00375
7/18	90	Black Lake	.249	.00902	.281	.00367
		Chignik Lake	.751	.00902	.719	.00367
7/20	62	Black Lake	.411	.01386	.291	.00344
		Chignik Lake	.589	.01386	.709	.00344
7/22	100	Black Lake	.212	.00804	.208	.00243
		Chignik Lake	.788	.00804	.792	.00243

Table 15. Stock composition estimates for the scale pattern analysis of the 1.3 age class in the 1979 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 6	27	Black Lake	.560	.05194	.691	.00837
		Chignik Lake	.440	.05194	.309	.00837
6/ 9	76	Black Lake	.513	.02335	.558	.01130
		Chignik Lake	.487	.02335	.442	.01130
6/16	60	Black Lake	.601	.02637	.679	.01008
		Chignik Lake	.399	.02637	.321	.01008
6/27	31	Black Lake	.923	.04101	.508	.01502
		Chignik Lake	.077	.04101	.492	.01502
7/ 3	19	Black Lake	-.158	.06778	.536	.01786
		Chignik Lake	1.158	.06778	.464	.01786
7/ 7	26	Black Lake	.686	.05195	.404	.02315
		Chignik Lake	.314	.05195	.596	.02315
7/ 8	15	Black Lake	.527	.08861	.574	.02209
		Chignik Lake	.473	.08861	.426	.02209
7/13	24	Black Lake	.508	.05823		
		Chignik Lake	.492	.05823		

Table 16. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1979 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 6	33	Black Lake	.808	.00766	.917	.00109
		Chignik Lake	.192	.00766	.083	.00109
6/ 9	81	Black Lake	.944	.00217	.886	.00148
		Chignik Lake	.056	.00217	.114	.00148
6/16	57	Black Lake	.905	.00346	.862	.00133
		Chignik Lake	.095	.00346	.138	.00133
6/27	46	Black Lake	.736	.00635	.662	.00149
		Chignik Lake	.264	.00635	.338	.00149
7/ 3	90	Black Lake	.345	.00357	.462	.00144
		Chignik Lake	.655	.00357	.538	.00144
7/ 7	100	Black Lake	.305	.00308	.280	.00102
		Chignik Lake	.695	.00308	.720	.00102
7/ 8	100	Black Lake	.190	.00251	.228	.00090
		Chignik Lake	.810	.00251	.772	.00090
7/13	100	Black Lake	.190	.00251	.167	.00079
		Chignik Lake	.810	.00251	.833	.00079
7/16	100	Black Lake	.121	.00205	.148	.00074
		Chignik Lake	.879	.00205	.852	.00074
7/18	100	Black Lake	.132	.00213	.144	.00074
		Chignik Lake	.868	.00213	.856	.00074
7/20	100	Black Lake	.178	.00244	.155	.00076
		Chignik Lake	.822	.00244	.845	.00076
7/22	100	Black Lake	.155	.00229	.111	.00053
		Chignik Lake	.845	.00229	.889	.00053

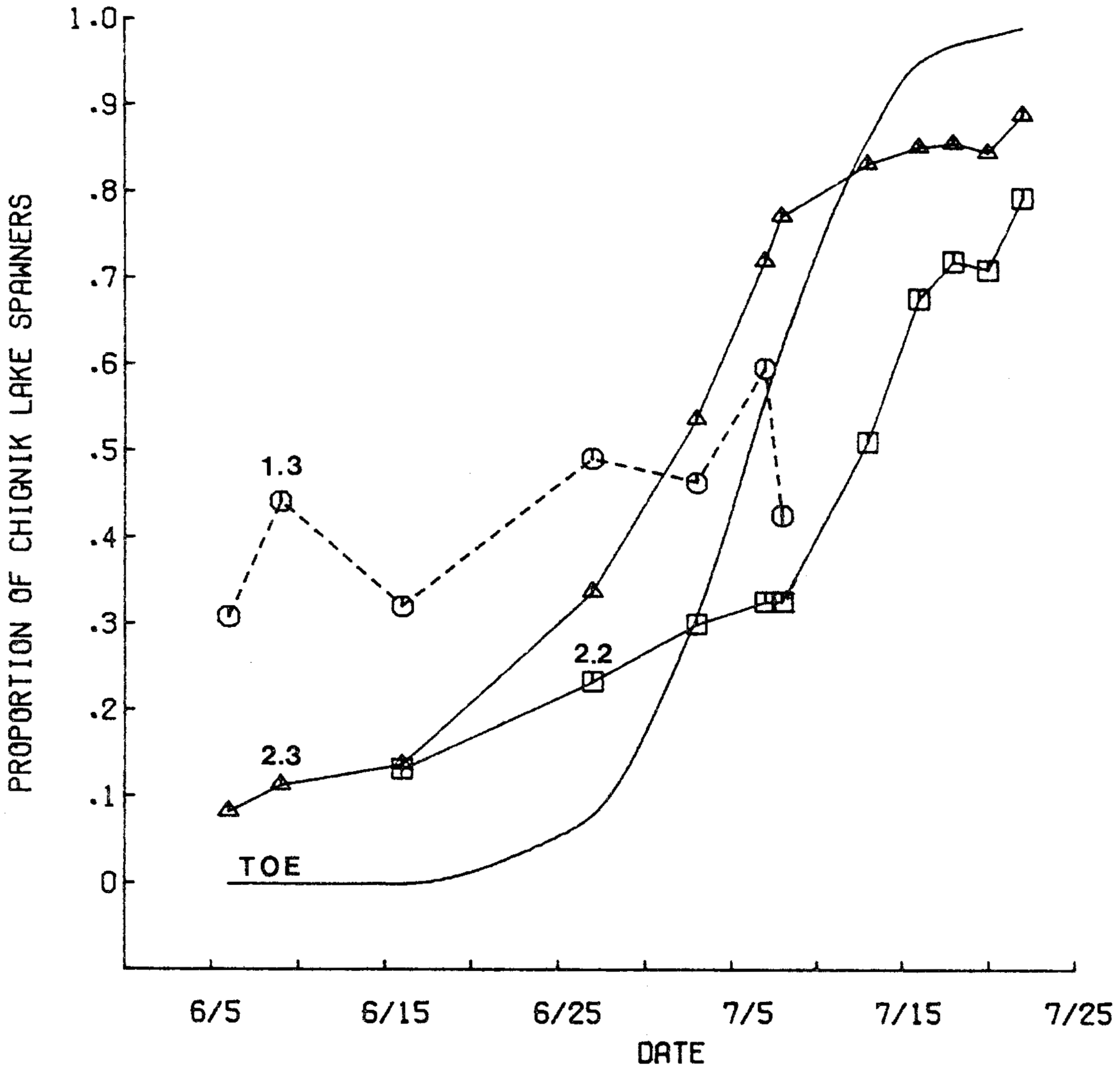

Figure 14. Daily stock composition during the period of transition for the age-specific stock composition estimates smoothed by a moving average of three sample dates. The average TOE curve used by ADF&G to separate the 1979 Chignik sockeye salmon run by stock is shown for comparison.

Table 17. Summary of the escapement, commercial catch, and total return by age class and stock for the 1979 Chignik sockeye salmon run estimated by analysis of scale patterns.

	Age											
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
Black Lake												
Escapement	247	953	12,758	69,160	652	99,993	199,401	1,748	0	782	0	385,694
%	0.06	0.25	3.31	17.93	0.17	25.93	51.70	0.45	0.00	0.20	0.00	100.00
Catch	259	824	6,686	45,245	735	20,297	116,470	748	0	27	0	191,291
%	0.14	0.43	3.50	23.65	0.38	10.61	60.89	0.39	0.00	0.01	0.00	100.00
Total	506	1,777	19,444	114,405	1,387	120,290	315,871	2,496	0	809	0	576,985
%	0.09	0.31	3.37	19.83	0.24	20.85	54.74	0.43	0.00	0.14	0.00	100.00
Chignik Lake												
Escapement	342	1,143	7,653	43,481	965	67,543	229,469	1,276	0	250	0	352,122
%	0.10	0.33	2.17	12.35	0.27	19.18	65.17	0.36	0.00	0.07	0.00	100.00
Catch	728	5,768	16,158	147,574	2,771	34,776	662,643	2,311	0	9	0	872,738
%	0.08	0.66	1.85	16.91	0.32	3.98	75.93	0.27	0.00	T[1]	0.00	100.00
Total	1,070	6,911	23,811	191,055	3,736	102,319	892,112	3,587	0	259	0	1,224,860
%	0.09	0.57	1.94	15.60	0.31	8.35	72.83	0.29	0.00	0.02	0.00	100.00

[1] Trace < 0.005%.

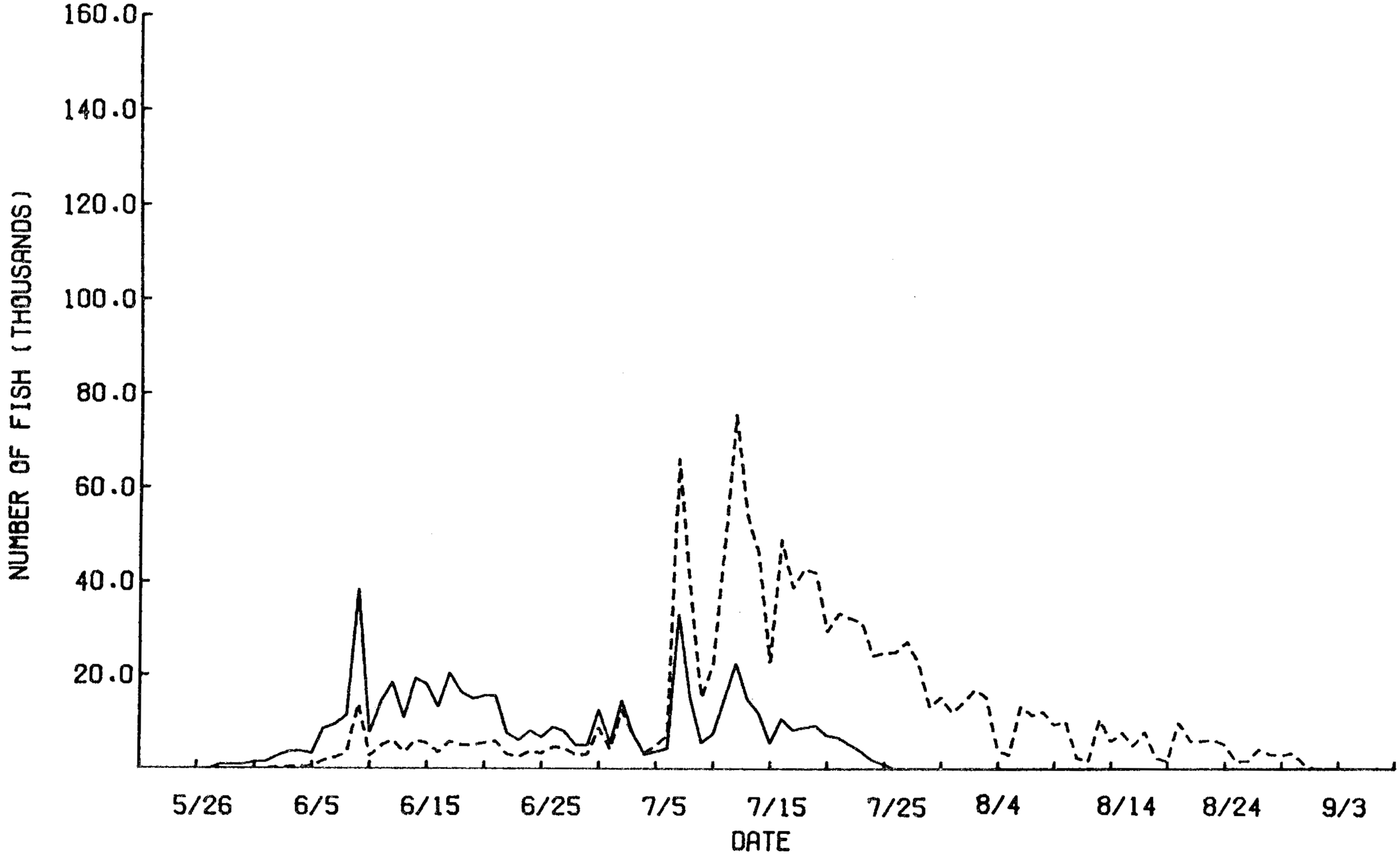

Figure 15. Total daily abundance of the Black Lake (——) and Chignik Lake (---) stocks in the 1979 Chignik sockeye salmon run.

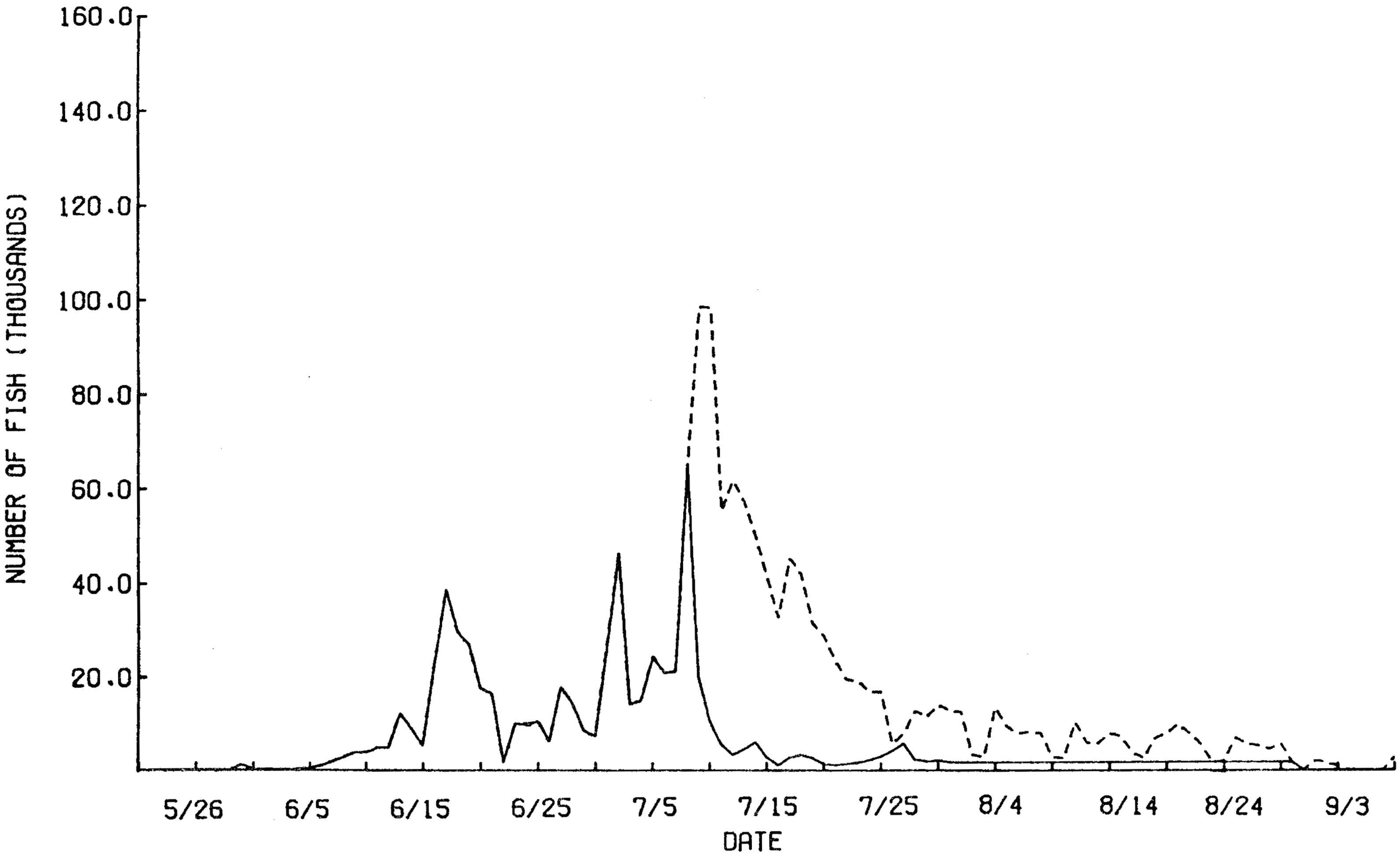

Figure 16. Daily escapement (——) and total daily abundance (---), adjusted to Chignik Lagoon date, for the 1980 Chignik sockeye salmon run

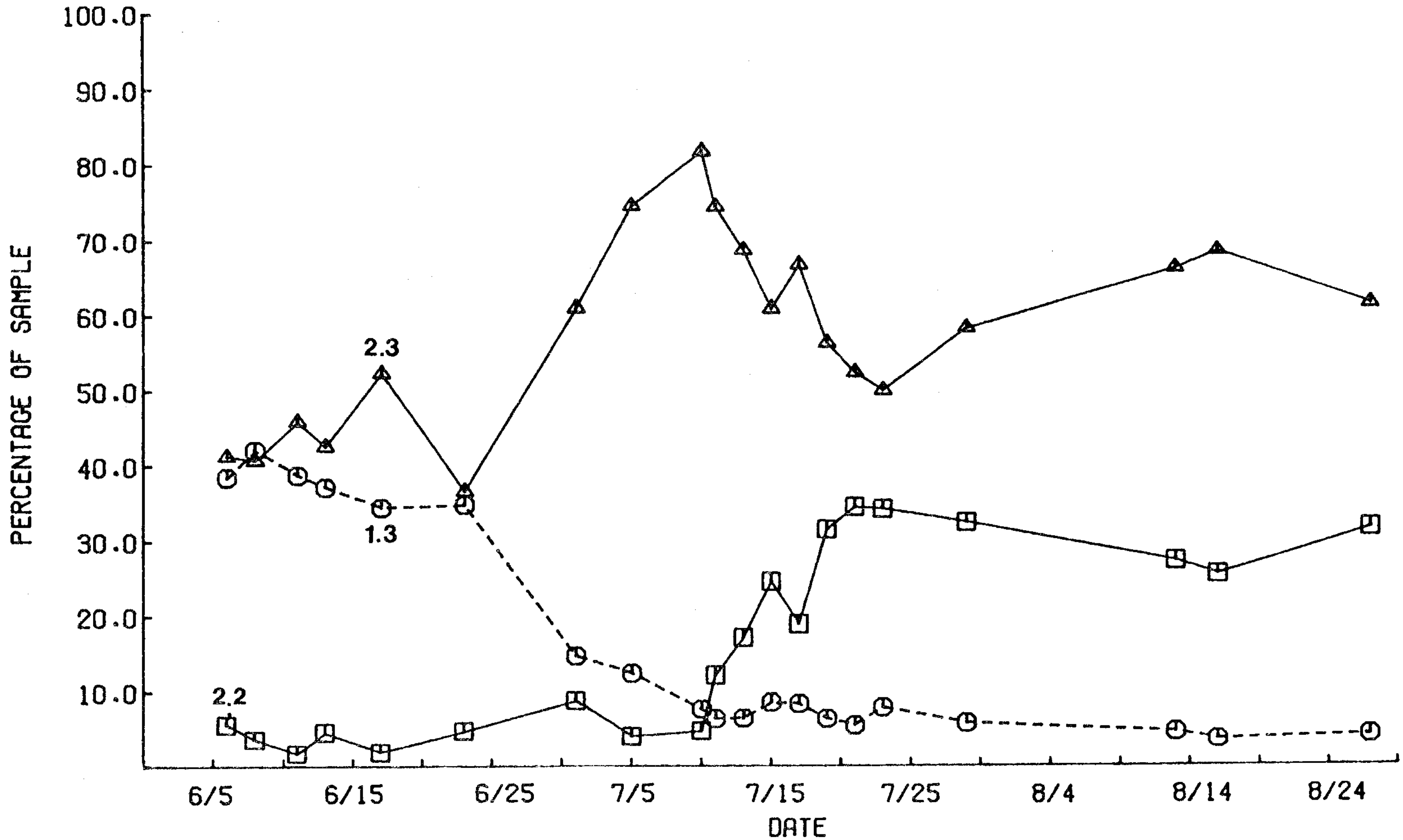

Figure 17. Age composition of scale samples collected in Chignik Lagoon during the 1980 sockeye salmon run, by sample date. Minor age groups are not shown.

Black Lake and Chignik Lake standards were established for the 2.2, 1.3, and 2.3 age classes in the 1980 run. The classification accuracies of the linear discriminant functions were 85.4% for the 2.2 age class, 74.8% for the 1.3 age class, and 83.8% for the 2.3 age class (Table 18). The scale characters selected for each age-specific LDF, and their mean and standard deviation for each stock, are given in Table 19.

Scale samples of unknown stock composition are analyzed for the 2.2, 1.3, and 2.3 age classes in the 1980 run. The sample sizes of the 2.2 age class were not large enough for analysis until July. Tables 20-22 summarize the adjusted stock composition estimates and the smoothed stock composition estimates for each of the analyzed age classes. The average TOE curve used by ADF&G in 1980 is compared to the smoothed daily stock composition estimates for the 2.2, 1.3, and 2.3 age classes in Figure 18.

In 1980, 466,092 sockeye salmon were assigned to the Black Lake stock. There were 311,332 salmon allocated to the Black Lake escapement and 154,760 fish of Black Lake origin were taken in the commercial catch (Table 23). Age 2.3 salmon were the most abundant age group in the 1980 Black Lake run with more than 60% of the run assigned to this age class. This is very unusual for the Black Lake run which is typically dominated by age 1.3 salmon. The total Chignik Lake run was 1,058,384. The escapement to Chignik Lake spawning areas was 352,729 fish and there were 705,655 Chignik Lake spawners taken in the commercial catch (Table 23). Typical of the Chignik Lake stock, the 2.3 age class was the most abundant age class in the run. Because of the poor Black Lake return in 1980, the Black Lake stock was more abundant than the Chignik Lake stock in the daily returns only during early June. From 17 June until 7 July the stocks were nearly equally abundant (Figure 19, Appendix Tables 5d and 5e) and after 7 July the Chignik Lake stock was more abundant.

1981:

A total of 2,942,342 sockeye salmon returned to Chignik in 1981. This was the largest total run recorded since 1947. There was an escapement of 831,449 salmon and a total commercial catch of 2,110,893 (Appendix Table 6a). Two discrete peaks of abundance were evident in the 1981 run, one on 9 June and one on 10 July (Figure 20). The early-arriving and late-arriving portions of the Chignik run were approximately equal in magnitude in 1981.

Scale samples for age and stock composition estimates were collected in Chignik Lagoon on 20 separate days between 3 June and 27 August (Appendix Table 6b). The sampling effort was evenly distributed throughout the period of high daily abundance from 3 June to 12 July. Ages were assigned to 4,977 (85.4%) of the 5,829 sockeye salmon scales collected in Chignik Lagoon. The change in the relative abundance of the major age classes present in Chignik Lagoon followed the pattern typical of the Chignik run (Figure 21).

Scale samples to construct the Black Lake standards for the LDF analyses were collected at the outlet of Black Lake on six sampling days in June (Appendix Table 6c). Ages were assigned to 87.8% of the 1,233 scales collected. As is expected for the Black Lake stock, age 1.3 fish were the dominant age group in the Black Lake samples with approximately 75% of the scales assigned to that age class.

Table 18. Classification matrices for age 2.2, 1.3, and 2.3 sockeye salmon in the 1980 Chignik run.

Age 2.2

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.833	0.126
Chignik Lake	0.167	0.874
Sample size	36	151

Mean classification = 0.854

Age 1.3

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.735	0.240
Chignik Lake	0.265	0.760
Sample size	200	25

Mean classification = 0.748

Age 2.3

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.820	0.145
Chignik Lake	0.180	0.855
Sample size	200	200

Mean classification = 0.838

Table 19. Scale characters selected for the final discriminant functions used to classify the 2.2, 1.3, and 2.3 age classes in the 1980 Chignik sockeye salmon run. (C = circulus, FW = freshwater, AZ = annular zone).

Age 2.2

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. total number of circuli in 1st and 2nd FW AZ	14.4	1.9	11.6	1.2
2. relative size, distance C1-C3 1st FW AZ	0.25	0.05	0.32	0.05
3. relative size, width of the widest pair of circuli in the 1st FW AZ	0.14	0.03	0.18	0.03
Sample size	36		151	

Equality of covariance matrices, significant $\alpha \leq 0.05$

Age 1.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. total number circuli in FW zone	10.1	1.4	8.8	1.5
2. width of 1st FW AZ	210.9	31.1	210.5	39.1
3. distance focus to C1, 1st FW AZ	53.5	6.6	58.4	9.3
4. average interval between circuli in the 1st FW AZ	23.9	2.2	25.2	3.2
Sample size	200		25	

Equality of covariance matrices, significant $\alpha \leq 0.05$

Age 2.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. total width of FW growth zone	331.9	28.0	287.7	31.1
2. total width of FW annular zone	320.8	28.3	285.1	31.2
3. relative size, distance focus to C5 1st FW AZ	0.70	0.10	0.84	0.10
4. relative size, distance C2 to C5 1st FW AZ	0.30	0.05	0.36	0.05
Sample size	200		200	

Equality of covariance matrices, significant $\alpha \leq 0.01$

Table 20. Stock composition estimates for the scale pattern analysis of the 2.2 age class in the 1980 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
7/11	28	Black Lake	.428	.01939		
		Chignik Lake	.572	.01939		
7/13	46	Black Lake	.345	.01168	.337	.00450
		Chignik Lake	.655	.01168	.663	.00450
7/15	51	Black Lake	.238	.00943	.283	.00338
		Chignik Lake	.762	.00943	.717	.00338
7/17	54	Black Lake	.267	.00933	.308	.00289
		Chignik Lake	.733	.00933	.692	.00289
7/19	90	Black Lake	.419	.00727	.331	.00251
		Chignik Lake	.581	.00727	.669	.00251
7/21	99	Black Lake	.308	.00599	.347	.00215
		Chignik Lake	.692	.00599	.653	.00215
7/23	98	Black Lake	.313	.00607	.207	.00134
		Chignik Lake	.687	.00607	.793	.00134

Table 21. Stock composition estimates for the scale pattern analysis of the 1.3 age class in the 1980 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 6	26	Black Lake	.292	.05241	.586	.00908
		Chignik Lake	.708	.05241	.414	.00908
6/ 8	51	Black Lake	.466	.02930	.420	.01278
		Chignik Lake	.534	.02930	.580	.01278
6/11	41	Black Lake	.501	.03329	.559	.00969
		Chignik Lake	.499	.03329	.441	.00969
6/13	49	Black Lake	.711	.02462	.508	.01133
		Chignik Lake	.289	.02462	.492	.01133
6/17	33	Black Lake	.311	.04405	.542	.01048
		Chignik Lake	.689	.04405	.458	.01048
6/23	52	Black Lake	.603	.02564	.305	.01543
		Chignik Lake	.397	.02564	.695	.01543
7/ 1	19	Black Lake	-.060	.06914	.533	.01688
		Chignik Lake	1.060	.06914	.467	.01688
7/ 5	15	Black Lake	.997	.05716	.470	.02147
		Chignik Lake	.003	.05716	.530	.02147
7/10	18	Black Lake	.413	.06692	.477	.02228
		Chignik Lake	.587	.06692	.523	.02228
7/11	16	Black Lake	.020	.07641	.144	.02370
		Chignik Lake	.980	.07641	.856	.02370
7/13	18	Black Lake	-.260	.06996	.007	.02376
		Chignik Lake	1.260	.06996	.993	.02376
7/15	20	Black Lake	-.081	.06746	.038	.02138
		Chignik Lake	1.081	.06746	.962	.02138
7/17	27	Black Lake	.114	.05496	.038	.02170
		Chignik Lake	.886	.05496	.962	.02170
7/19	17	Black Lake	-.128	.07286	.038	.02207
		Chignik Lake	1.128	.07286	.962	.02207
7/21	18	Black Lake	-.148	.07083	.063	.02236
		Chignik Lake	1.148	.07083	.937	.02236
7/23	24	Black Lake	.189	.05754	.063	.01426
		Chignik Lake	.811	.05754	.937	.01426

Table 22. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1980 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 6	23	Black Lake	.558	.02458	.766	.00408
		Chignik Lake	.442	.02458	.234	.00408
6/ 8	45	Black Lake	.740	.01215	.694	.00544
		Chignik Lake	.260	.01215	.306	.00544
6/11	43	Black Lake	.784	.01227	.733	.00398
		Chignik Lake	.216	.01227	.267	.00398
6/13	50	Black Lake	.674	.01142	.751	.00395
		Chignik Lake	.326	.01142	.249	.00395
6/17	44	Black Lake	.795	.01190	.751	.00380
		Chignik Lake	.205	.01190	.249	.00380
6/23	49	Black Lake	.783	.01091	.705	.00362
		Chignik Lake	.217	.01091	.295	.00362
7/ 1	61	Black Lake	.538	.00975	.578	.00319
		Chignik Lake	.462	.00975	.422	.00319
7/ 5	73	Black Lake	.414	.00809	.468	.00267
		Chignik Lake	.586	.00809	.532	.00267
7/10	100	Black Lake	.452	.00617	.405	.00225
		Chignik Lake	.548	.00617	.595	.00225
7/11	100	Black Lake	.348	.00595	.314	.00191
		Chignik Lake	.652	.00595	.686	.00191
7/13	100	Black Lake	.141	.00504	.225	.00181
		Chignik Lake	.859	.00504	.775	.00181
7/15	100	Black Lake	.185	.00528	.111	.00161
		Chignik Lake	.815	.00528	.889	.00161
7/17	100	Black Lake	.007	.00414	.064	.00144
		Chignik Lake	.993	.00414	.936	.00144
7/19	100	Black Lake	-.067	.00353	.015	.00134
		Chignik Lake	1.067	.00353	.985	.00134
7/21	100	Black Lake	.037	.00436	.030	.00137
		Chignik Lake	.963	.00436	.970	.00137
7/23	100	Black Lake	.052	.00447	.030	.00098
		Chignik Lake	.948	.00447	.970	.00098

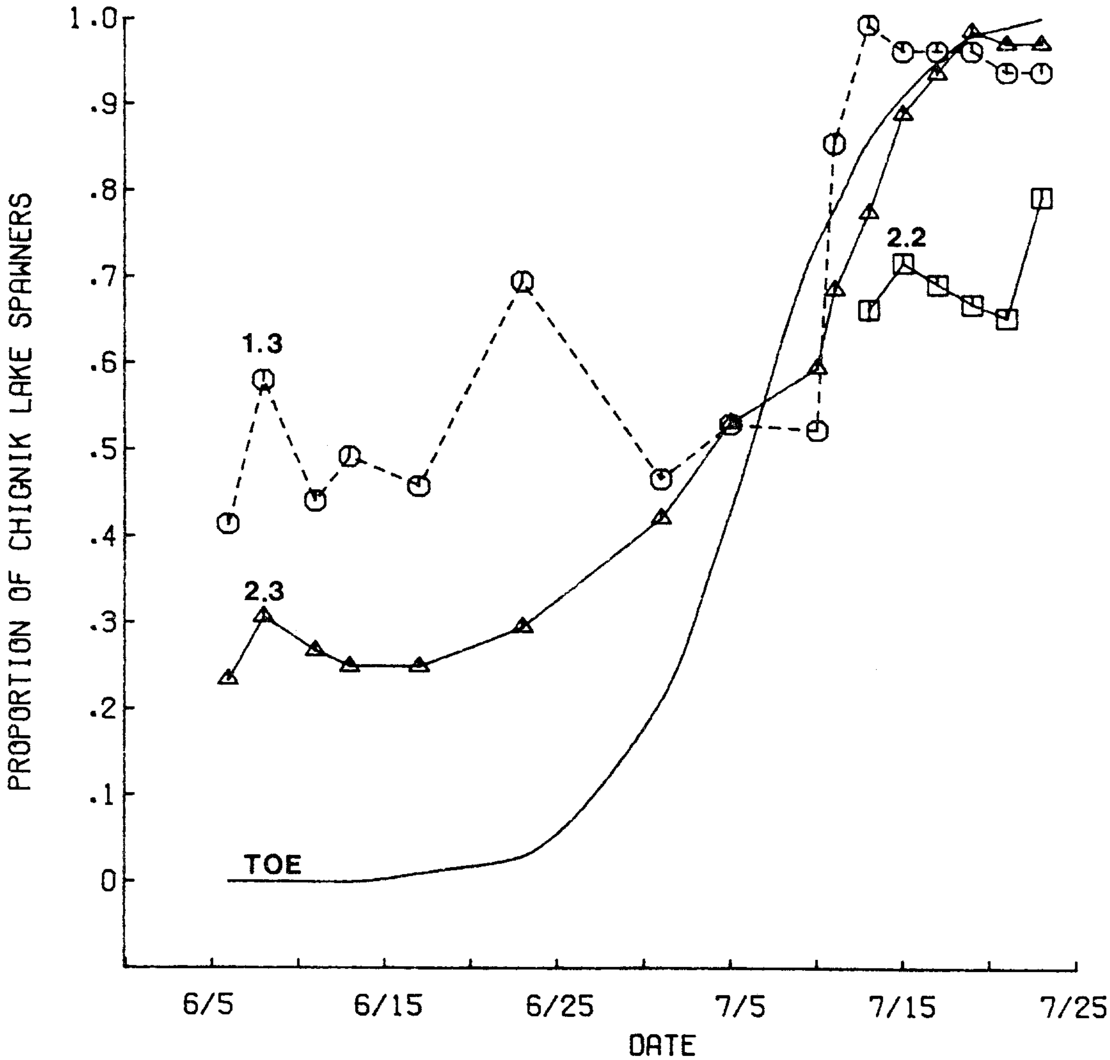

Figure 18. Daily stock composition during the period of transition for the age-specific stock composition estimates smoothed by a moving average of three sample dates. The average TOE curve used by ADF&G to separate the 1980 Chignik sockeye salmon run by stock is shown for comparison.

Table 23. Summary of the escapement, commercial catch, and total return by age class and stock for the 1980 Chignik sockeye salmon run estimated by analysis of scale patterns.

	Age											
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
Black Lake												
Escapement	67	7	35,822	17,289	152	60,891	194,137	748	112	178	1,929	311,332
%	0.02	T[1]	11.51	5.55	0.05	19.56	62.36	0.24	0.03	0.06	0.62	100.00
Catch	32	78	6,811	36,320	381	8,479	100,911	1,004	0	316	428	154,760
%	0.02	0.05	4.40	23.47	0.25	5.48	65.20	0.65	0.00	0.20	0.28	100.00
Total	99	85	42,633	53,609	533	69,370	295,048	1,752	112	494	2,357	466,092
%	0.02	0.02	9.15	11.50	0.11	14.88	63.30	0.38	0.02	0.11	0.51	100.00
Chignik Lake												
Escapement	51	120	31,481	39,744	418	72,600	205,225	1,199	51	322	1,518	352,729
%	0.01	0.03	8.93	11.27	0.12	20.58	58.18	0.34	0.02	0.09	0.43	100.00
Catch	201	687	27,810	145,758	1,619	51,109	472,797	3,560	0	927	1,187	705,655
%	0.03	0.10	3.94	20.66	0.23	7.24	67.00	0.50	0.00	0.13	0.17	100.00
Total	252	807	59,291	185,502	2,037	123,709	678,022	4,759	51	1,249	2,705	1,058,384
%	0.02	0.08	5.60	17.53	0.19	11.69	64.06	0.45	T[1]	0.12	0.26	100.00

[1] Trace < 0.005%

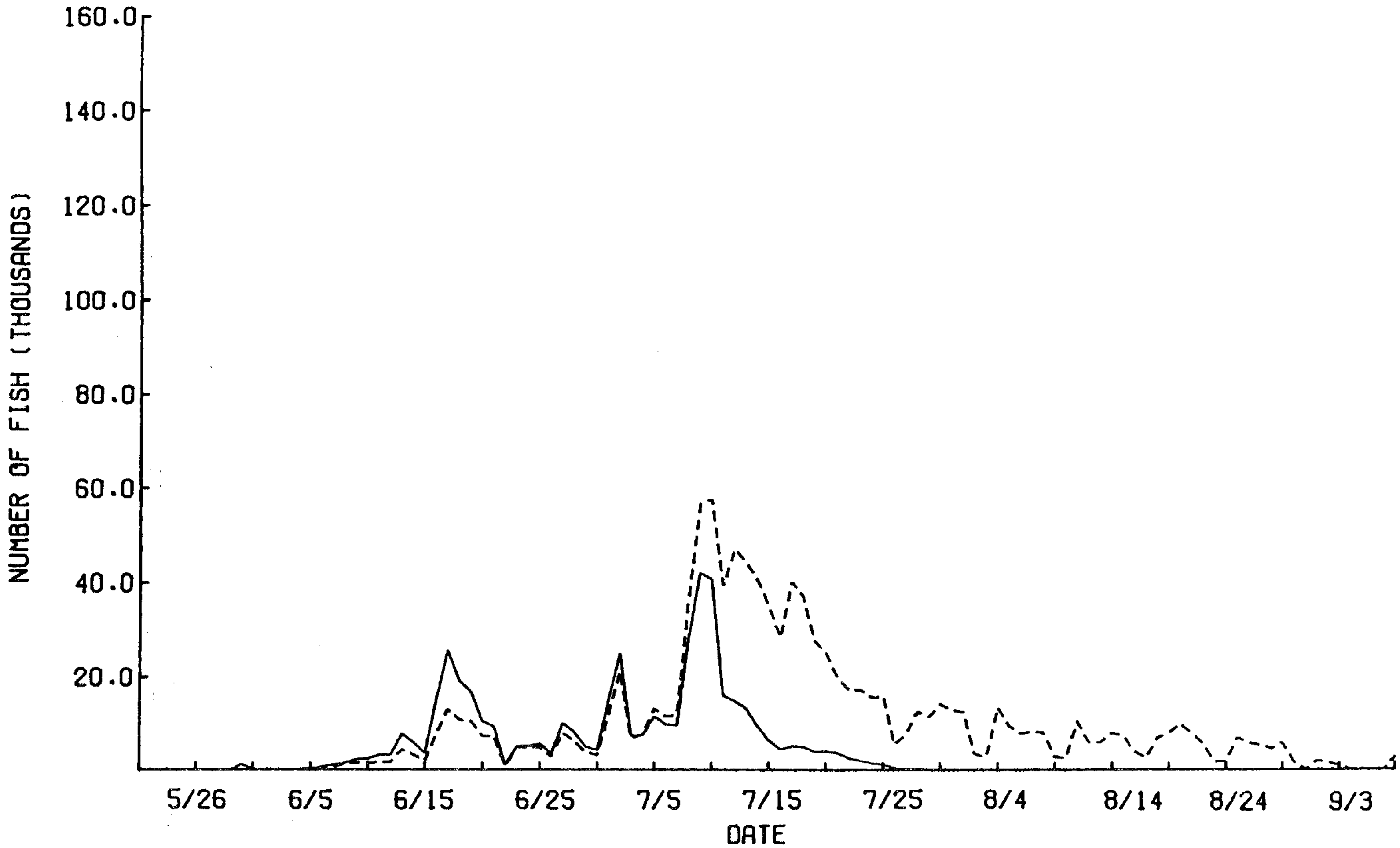

Figure 19. Total daily abundance of the Black Lake (——) and Chignik Lake (---) stocks in the 1980 Chignik sockeye salmon run.

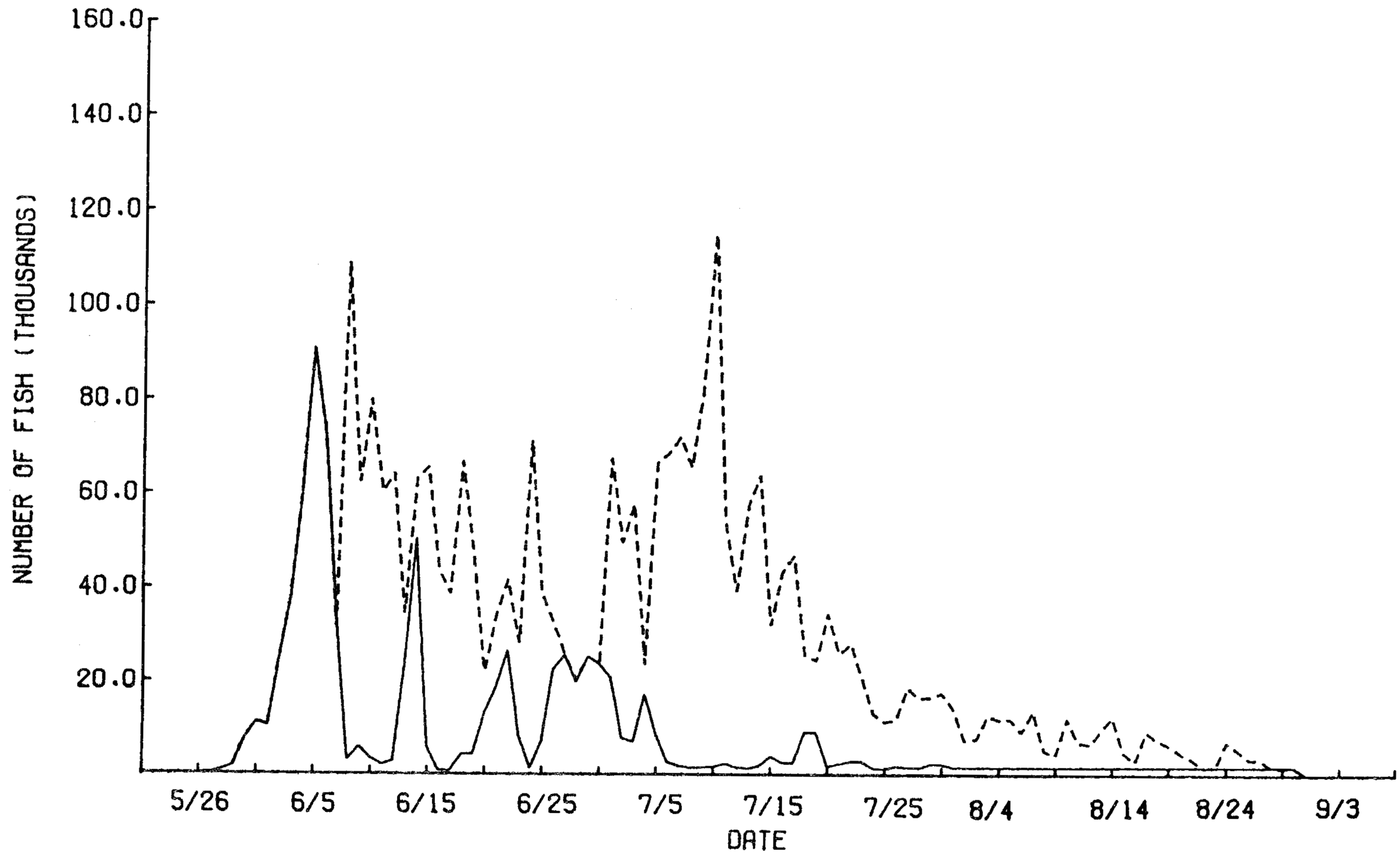

Figure 20. Daily escapement (——) and total daily abundance (---), adjusted to Chignik Lagoon date, for the 1981 Chignik sockeye salmon run.

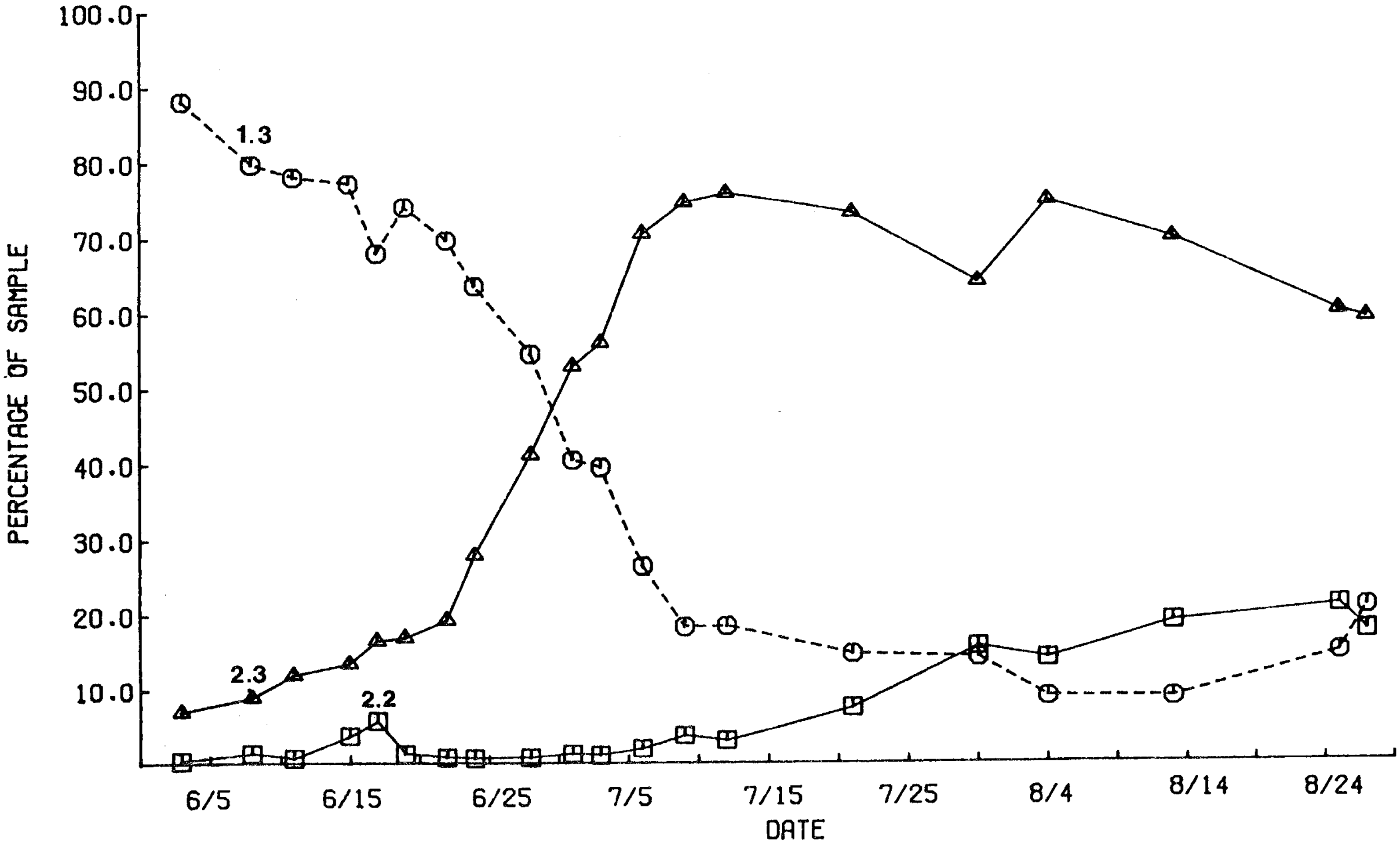

Figure 21. Age composition of scale samples collected in Chignik Lagoon during the 1981 sockeye salmon run, by sample date. Minor age groups are not shown.

Standards for the Black Lake stock could be established only for the 1.3 and 2.3 age classes in 1981. For Chignik Lake, standards were constructed for the 2.2, 1.3, and 2.3 age classes. Classification accuracies of the LDFs for the 1.3 and 2.3 age classes were 74.9% and 79.6%, respectively (Table 24). The scale characters selected for each age-specific LDF, and the mean and standard deviation of each character by stock, are presented in Table 25.

The stock composition estimates for the 1.3 and 2.3 age classes for the scale samples of unknown stock composition collected in Chignik Lagoon in 1981 are summarized in Tables 26 and 27. The shifted TOE curve used by ADF&G to separate the stocks in 1981 is compared to the smoothed daily stock composition estimates for the 1.3 and 2.3 age classes in Figure 22.

The total Black Lake run in 1981 was 1,157,519 sockeye salmon, with an escapement of 438,540 and total catch of 718,979 (Table 28). The 1.3 and 2.3 age classes were the most abundant in the Black Lake stock, composing 54.9% and 36.7% of the total run, respectively. A total of 1,784,823 salmon were assigned to the Chignik Lake stock. The escapement to Chignik Lake spawning areas was 392,909 salmon and there were 1,391,914 fish of Chignik Lake origin taken in the commercial catch (Table 28). Atypical of the Chignik Lake stock was the nearly equal abundance of 1.3 and 2.3 age classes which accounted for about 90% of the total Chignik Lake run. The daily abundance by stock in 1981 was somewhat unusual for the Chignik sockeye salmon run because there was a great degree of overlap between the two stocks (Figure 23, Appendix Tables 6d and 6e).

1982:

The total sockeye salmon run to Chignik in 1982 was 2,514,582. There was 837,718 salmon in the escapement and a total catch of 1,676,864 (Appendix Table 7a). The early arriving portion of the run was very abundant from 13 June to 30 June and had a peak daily abundance of 337,305 on 18 June (Figure 24). The return of the late arriving portion of the run was very poor in 1982. After 7 July, the total daily return never exceeded 32,000 salmon.

Scale samples for age and stock composition estimates were collected in Chignik Lagoon on 15 separate occasions from 7 June to 23 August (Appendix Table 7b). The sampling effort was evenly distributed throughout June and July when the majority of the run returned. Of the 4,341 sockeye salmon scales collected, 3,550 (81.8%) were legible for aging. The change in the relative abundance of the major age classes present in Chignik Lagoon followed the pattern typical of the Chignik run (Figure 25).

Scale samples were collected at Black Lake outlet on four days during late June and July and early July (Appendix Table 7c). Ages were assigned to 83.4% of the 1,172 scales collected. The 1.3 age class dominated the Black Lake samples as more than 75% of each sample was assigned to it.

Only the 1.3 and 2.3 age classes were abundant enough in the Black Lake samples to establish standards. The classification accuracy of each age-specific LDF was 75.8% for the 1.3 age class and 82.6% for the 2.3 age class (Table 29). A summary of the scale characters selected for each age-specific LDF is given in Table 30.

Table 24. Classification matrices for age 1.3 and 2.3 sockeye salmon in the 1981 Chignik run.

Age 1.3

Classified stock of origin	Actual stock of origin	
	Black Lake	Chignik Lake
Black Lake	0.760	0.262
Chignik Lake	0.240	0.738
Sample size	200	126
	Mean classification = 0.749	

Age 2.3

Classified stock of origin	Actual stock of origin	
	Black Lake	Chignik Lake
Black Lake	0.786	0.195
Chignik Lake	0.214	0.805
Sample size	140	200
	Mean classification = 0.796	

Table 25. Scale characters selected for the final discriminant functions used to classify the 1.3 and 2.3 age classes in the 1981 Chignik sockeye salmon run. (C = circulus, FW = freshwater, AZ = annular zone)[1].

Age 1.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. distance focus to C4, 1st FW AZ	130.1	15.2	114.5	14.2
2. ratio, width 1st FW AZ to width total FW growth zone	0.89	0.07	0.82	0.13
3. relative size, distance 3rd C before end of 1st FW AZ to end of 1st FW AZ	0.23	0.05	0.29	0.08
4. number of circuli in 1st FW AZ	8.4	1.4	7.5	1.9
5. relative size, distance C1 to C4 1st FW AZ	0.35	0.05	0.37	0.07
6. distance C2 to C4, 1st FW AZ	46.7	8.5	39.7	7.5
7. average interval between circuli in the 1st FW AZ	24.6	2.5	23.2	2.5
Sample size	200		126	

Equality of covariance matrices, significant $\alpha \leq 0.01$

Age 2.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. ratio, total FW annular growth to total FW growth zone	0.99	0.04	0.95	0.04
2. distance end of 1st FW AZ to C2 2nd FW AZ	36.0	6.3	41.1	5.9
3. distance focus to C1, 1st FW AZ	57.7	7.4	54.7	5.5
4. relative size, distance C2 to C4 1st FW AZ	0.25	0.04	0.27	0.03
Sample size	140		200	

Equality of covariance matrices, significant $\alpha \leq 0.01$

[1] All linear distances reported in 0.01's of inches at 210X.

Table 26. Stock composition estimates for the scale pattern analysis of the 1.3 age class in the 1981 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 3	100	Black Lake	.799	.01165	.806	.00265
		Chignik Lake	.201	.01165	.194	.00265
6/ 8	100	Black Lake	.618	.01219	.625	.00406
		Chignik Lake	.382	.01219	.375	.00406
6/11	100	Black Lake	.458	.01267	.444	.00423
		Chignik Lake	.542	.01267	.556	.00423
6/15	100	Black Lake	.257	.01325	.378	.00430
		Chignik Lake	.743	.01325	.622	.00430
6/17	100	Black Lake	.418	.01278	.431	.00425
		Chignik Lake	.582	.01278	.569	.00425
6/19	100	Black Lake	.618	.01219	.511	.00417
		Chignik Lake	.382	.01219	.489	.00417
6/22	100	Black Lake	.498	.01255	.478	.00420
		Chignik Lake	.502	.01255	.522	.00420
6/24	100	Black Lake	.317	.01308	.384	.00429
		Chignik Lake	.683	.01308	.616	.00429
6/28	100	Black Lake	.337	.01302	.250	.00461
		Chignik Lake	.663	.01302	.750	.00461
7/ 1	84	Black Lake	.095	.01536	.178	.00468
		Chignik Lake	.905	.01536	.822	.00468
7/ 3	99	Black Lake	.103	.01378	.131	.00531
		Chignik Lake	.897	.01378	.869	.00531
7/ 6	64	Black Lake	.196	.01865	.192	.00668
		Chignik Lake	.804	.01865	.808	.00668
7/ 9	40	Black Lake	.277	.02771	.182	.00774
		Chignik Lake	.723	.02771	.818	.00774
7/12	47	Black Lake	.072	.02329	.257	.00907
		Chignik Lake	.928	.02329	.743	.00907
7/21	36	Black Lake	.422	.03064	.165	.00599
		Chignik Lake	.578	.03064	.835	.00599

Table 27. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1981 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 3	18	Black Lake	1.080	.02612	.839	.00612
		Chignik Lake	-.080	.02612	.161	.00612
6/ 8	26	Black Lake	.516	.02897	.669	.00855
		Chignik Lake	.484	.02897	.331	.00855
6/11	35	Black Lake	.492	.02185	.661	.00761
		Chignik Lake	.508	.02185	.339	.00761
6/15	35	Black Lake	.975	.01770	.773	.00624
		Chignik Lake	.025	.01770	.227	.00624
6/17	43	Black Lake	.851	.01658	.775	.00553
		Chignik Lake	.149	.01658	.225	.00553
6/19	51	Black Lake	.499	.01545	.588	.00528
		Chignik Lake	.501	.01545	.412	.00528
6/22	50	Black Lake	.415	.01547	.517	.00464
		Chignik Lake	.585	.01547	.483	.00464
6/24	77	Black Lake	.637	.01080	.602	.00388
		Chignik Lake	.363	.01080	.398	.00388
6/28	100	Black Lake	.753	.00868	.613	.00311
		Chignik Lake	.247	.00868	.387	.00311
7/ 1	100	Black Lake	.448	.00849	.589	.00287
		Chignik Lake	.552	.00849	.411	.00287
7/ 3	100	Black Lake	.567	.00866	.482	.00284
		Chignik Lake	.433	.00866	.518	.00284
7/ 6	100	Black Lake	.431	.00845	.465	.00283
		Chignik Lake	.569	.00845	.535	.00283
7/ 9	100	Black Lake	.398	.00838	.381	.00277
		Chignik Lake	.602	.00838	.619	.00277
7/12	100	Black Lake	.313	.00814	.251	.00261
		Chignik Lake	.687	.00814	.749	.00261
7/21	100	Black Lake	.042	.00698	.118	.00168
		Chignik Lake	.958	.00698	.882	.00168

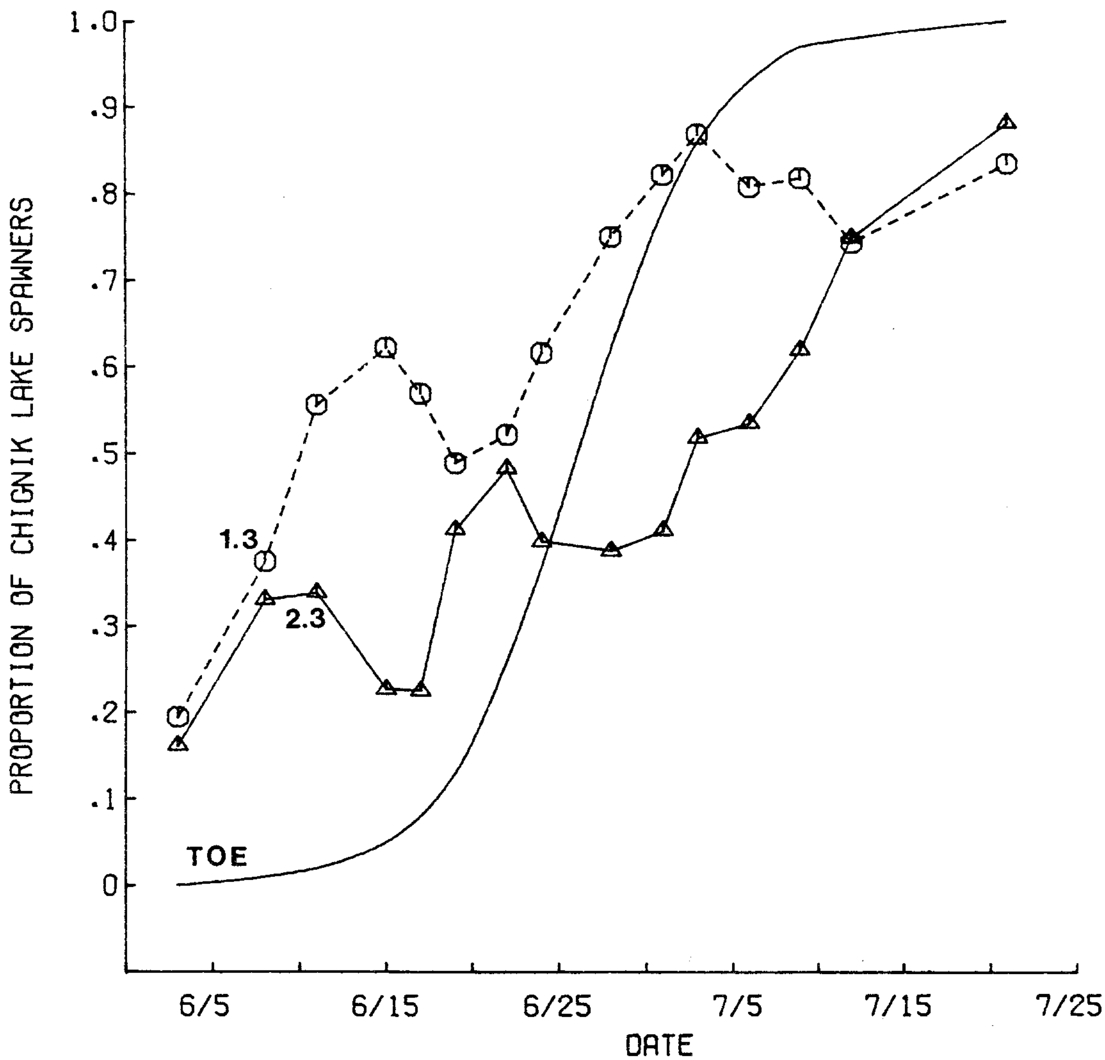

Figure 22. Daily stock composition during the period of transition for the age-specific stock composition estimates smoothed by a moving average of three sample dates. The average TOE curve (shifted ten days earlier) used by ADF&G to separate the 1981 Chignik sockeye salmon run by stock is shown for comparison.

Table 28. Summary of the escapement, commercial catch, and total return by age class and stock for the 1981 Chignik sockeye salmon run estimated by analysis of scale patterns.

	Age											
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
Black Lake												
Escapement	8	24	21,765	5,198	161	309,271	96,917	358	310	32	4,496	438,540
%	T[1]	0.01	4.96	1.19	0.04	70.52	22.10	0.08	0.07	0.01	1.02	100.00
Catch	215	346	34,492	18,374	843	326,730	328,005	2,233	650	397	6,694	718,979
%	0.03	0.05	4.80	2.56	0.12	45.44	45.62	0.31	0.09	0.05	0.93	100.00
Total	223	370	56,257	23,572	1,004	636,001	424,922	2,591	960	429	11,190	1,157,519
%	0.02	0.03	4.86	2.04	0.09	54.94	36.71	0.22	0.08	0.04	0.97	100.00
Chignik Lake												
Escapement	96	467	14,322	17,645	516	230,238	125,605	1,087	315	278	2,340	392,909
%	0.02	0.12	3.64	4.49	0.13	58.60	31.97	0.28	0.08	0.07	0.60	100.00
Catch	320	3,451	37,719	75,354	3,006	534,515	721,755	8,043	586	2,005	5,160	1,391,914
%	0.02	0.25	2.71	5.41	0.22	38.40	51.85	0.58	0.04	0.15	0.37	100.00
Total	416	3,918	52,041	92,999	3,522	764,753	847,360	9,130	901	2,283	7,500	1,784,823
%	0.02	0.22	2.91	5.21	0.20	42.85	47.48	0.51	0.05	0.13	0.42	100.00

[1] Trace < 0.005%

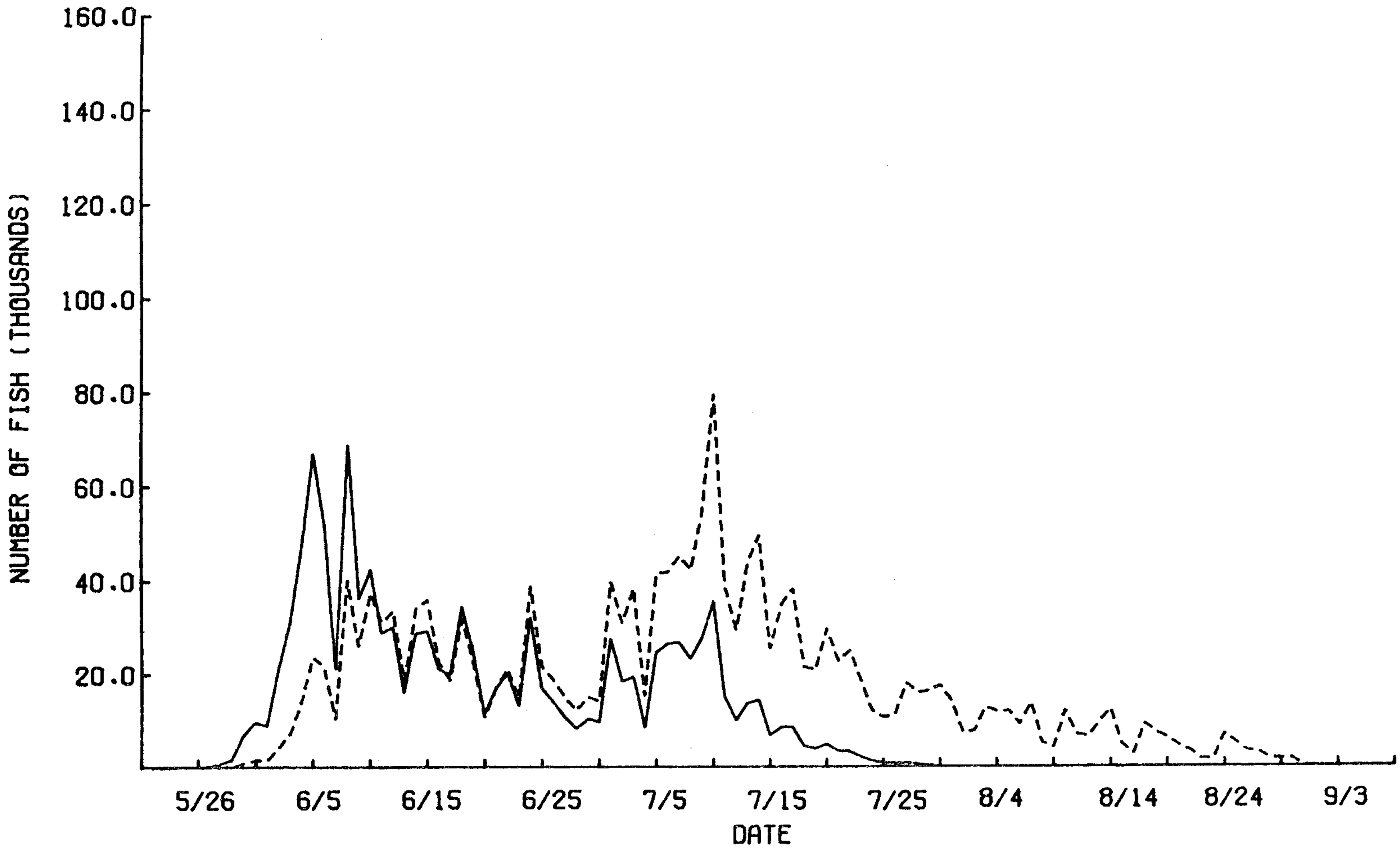

Figure 23. Total daily abundance of the Black Lake (——) and Chignik Lake (---) stocks in the 1981 Chignik sockeye salmon run.

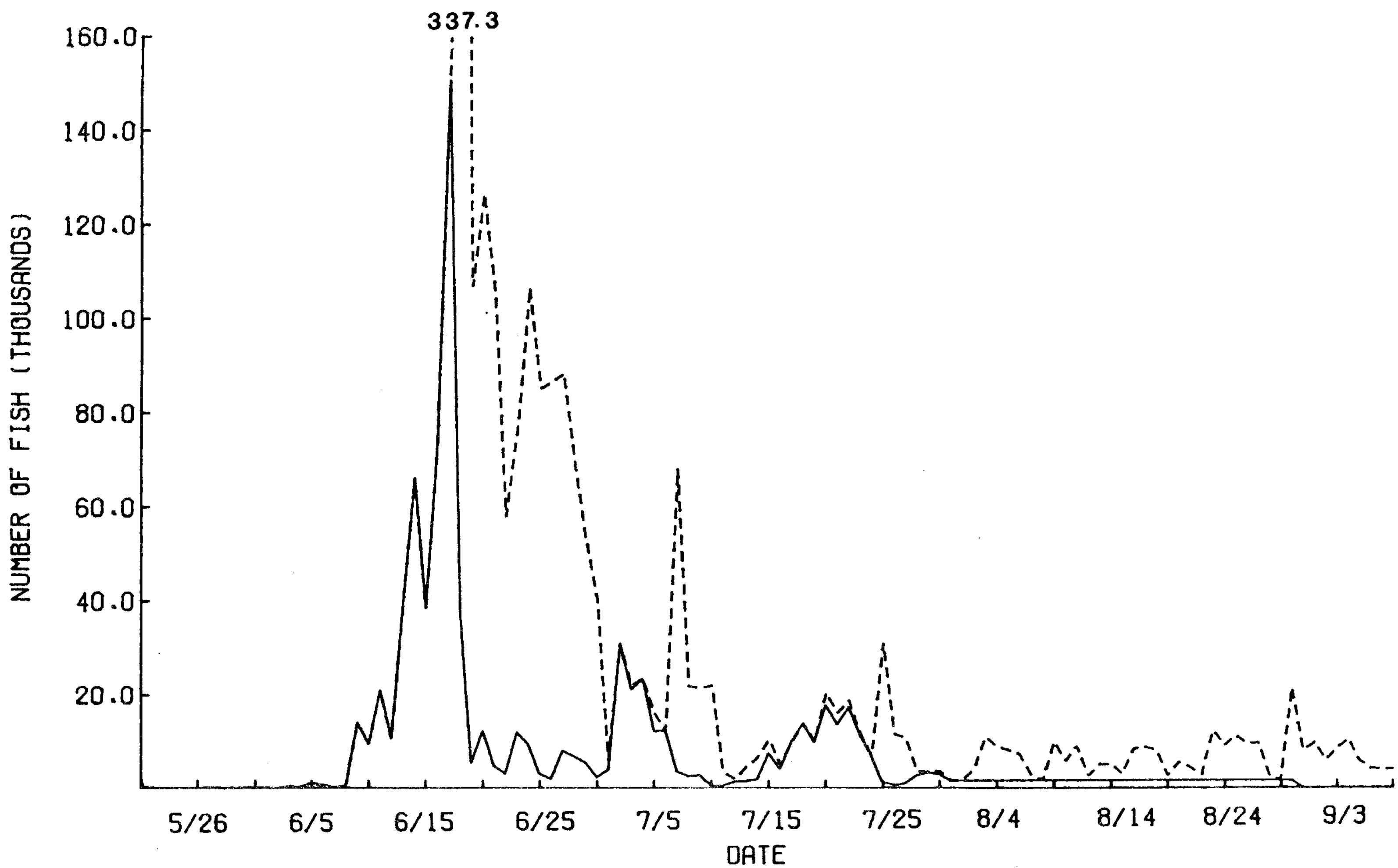

Figure 24. Daily escapement (——) and total daily abundance (---), adjusted to Chignik Lagoon date, for the 1982 Chignik sockeye salmon run.

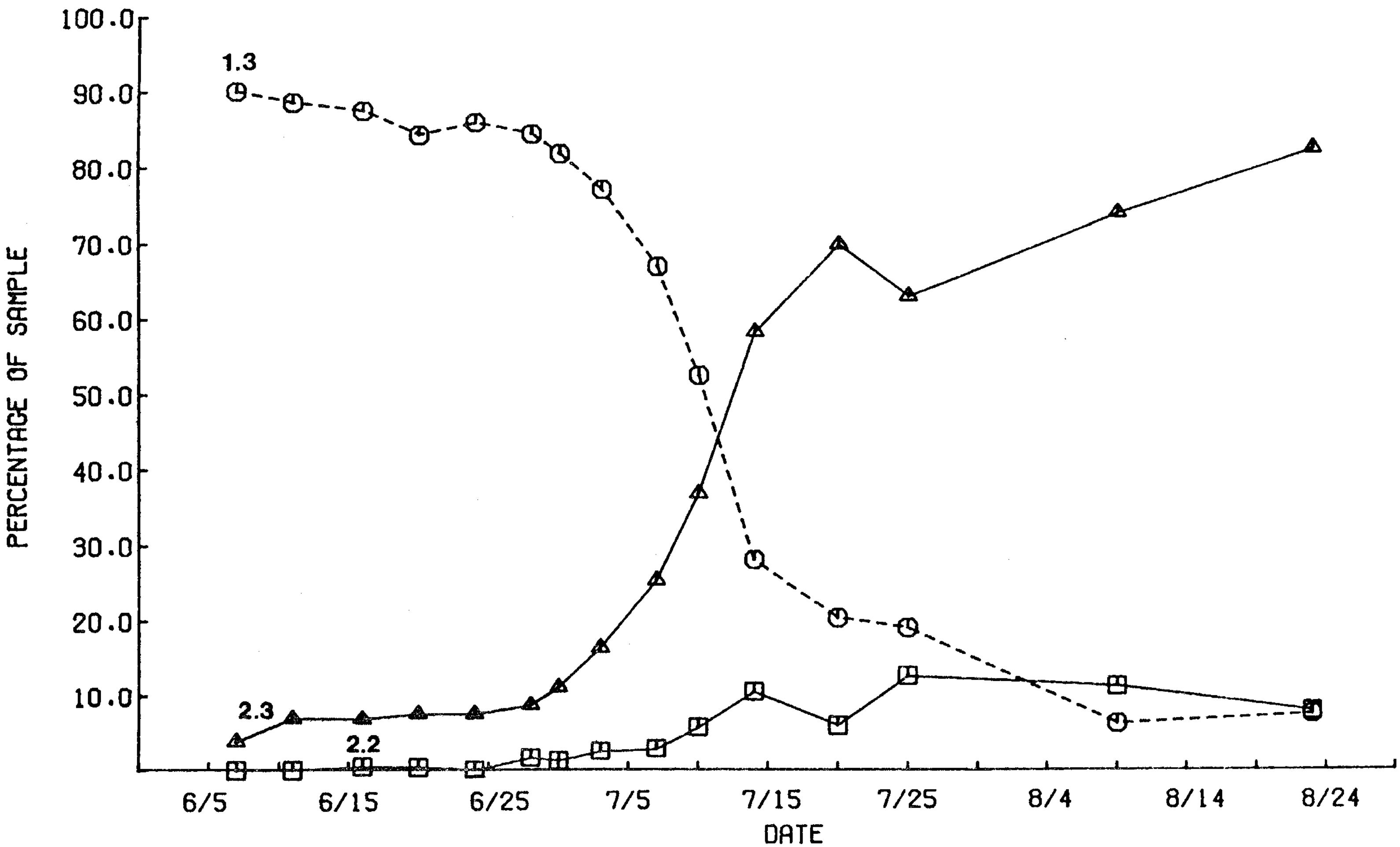

Figure 25. Age composition of scale samples collected in Chignik Lagoon during the 1982 sockeye salmon run, by sample date. Minor age groups are not shown.

Table 29. Classification matrices for age 1.3 and 2.3 sockeye salmon in the 1982 Chignik run.

Age 1.3

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.770	0.254
Chignik Lake	0.230	0.746
Sample size	200	67

Mean classification = 0.758

Age 2.3

Classified stock of origin	Actual stock of origin: Black Lake	Chignik Lake
Black Lake	0.777	0.125
Chignik Lake	0.223	0.875
Sample size	103	200

Mean classification = 0.826

Table 30. Scale characters selected for the final discriminant functions used to classify the 1.3 and 2.4 age classes in the 1982 Chignik sockeye salmon run. (C = circulus, FW = freshwater, AZ = annual zone)[1].

Age 1.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. total number of FW circuli	9.9	1.0	8.5	1.4
2. distance focus to C1, 1st FW AZ	57.3	7.3	52.1	8.1
3. ratio, width 1st FW AZ to total width FW growth zone	0.90	0.08	0.96	0.07
4. distance C2 to C5, 1st FW AZ	66.4	9.7	61.5	9.8
Sample size	200		67	

Equality of covariance matrices, significant $\alpha \leq 0.05$

Age 2.3

Scale characters selected	Black Lake $\bar{x}$	Black Lake s	Chignik Lake $\bar{x}$	Chignik Lake s
1. distance focus to C1, 1st FW AZ	56.6	7.1	52.9	5.7
2. distance C1 to C3, 2nd FW AZ	38.4	7.0	46.4	5.9
3. relative size, width of the widest pair of circuli in the 2nd FW AZ	0.20	0.03	0.18	0.02
Sample size	103		200	

Equality of covariance matrices, significant $\alpha \leq 0.01$

[1] All linear distances reported in 0.01's of inches at 210X.

The results of the LDF analyses of the 1.3 and 2.3 age classes for the samples of unknown stock composition are given in Tables 31 and 32. The age-specific stock composition estimates for the 1.3 and 2.3 age classes are shown in relation to the shifted TOE curve used by ADF&G in 1982 in Figure 26.

The total Black Lake run in 1982 was 1,867,322 salmon. The escapement to Black Lake spawning areas was 616,117 salmon and there were 1,251,205 fish of Black Lake origin taken in the commercial catch (Table 33). About 87% of the 1982 Black Lake run were age 1.3 salmon. Only 647,260 sockeye salmon of Chignik Lake origin returned in 1982. The escapement to Chignik Lake spawning areas was 221,601 and 425,659 fish belonging to the Chignik Lake stock were taken in the commercial catch (Table 33). The distribution of the daily abundance of each stock during the 1982 returns is shown in Figure 27 (Appendix Tables 7d and 7e).

Summary of the Post-season Analyses

A great diversity in the character of the five runs analyzed for this report is evident. The contribution of each stock to the total run: was approximately equal in 1978 and 1981; was dominated by the Chignik Lake stock in 1979 and 1980; and by the Black Lake stock in 1982. There was a difference of about one million fish between the smallest and largest runs observed for each stock during the years 1978-1982 (Tables 34 and 35). The relative abundance of the major age classes also varied considerably from year to year for both stocks. Although the majority of the Black Lake stock usually spent one year in freshwater and the majority of the Chignik Lake stock two years, there were important exceptions in some years. It is difficult to define generalities concerning the Chignik sockeye salmon runs during this period because of the unique influence of each stock on the total run. The return of a majority of the Black Lake stock in June and a majority of the Chignik Lake stock in July was consistent in all years. The degree of overlap in the run of the two stocks, however, was very different from year to year.

In-season Separation by Stock of the Chignik Sockeye Salmon Runs, 1979-1982

The in-season stock separation analyses could only be conducted after satisfactory standards representing the Chignik Lake stock were established. For each age class to be analyzed, a Chignik Lake standard with scale patterns similar to those in the actual return was needed. Two possibilities were examined for the representative standards: (1) using the previous year's 2.2 Chignik Lake standard to represent the 2.3 standard in the year of analysis; and (2) using a standard formed by pooling the Chignik Lake standards for either the 1.3 or 2.3 age classes from several years. The hypothesis of either of these approaches is that the difference between the scale growth characters of the representative Chignik Lake standard and the actual standard used in the post-season analysis, is significantly less than the difference between the Chignik Lake and Black Lake standards in the year of analysis. To evaluate each method of forming a representative standard, the mean scale growth characters for the representative standards and actual standards were compared.

Comparison of the 2.3 Chignik Lake Standards to the Previous Year's 2.2 Chignik Lake Standards

The mean scale growth characters for each set of 2.2-2.3 Chignik Lake standards were tested for equality by the Hotelling T^2 statistic. In each lacustrine

Table 31. Stock composition estimates for the scale pattern analysis of the 1.3 age class in the 1982 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 7	100	Black Lake	1.078	.00971	1.000	.00213
		Chignik Lake	-.078	.00971	0.000	.00213
6/11	100	Black Lake	1.155	.00948	1.000	.00320
		Chignik Lake	-.155	.00948	0.000	.00320
6/16	100	Black Lake	1.097	.00964	1.000	.00317
		Chignik Lake	-.097	.00964	0.000	.00317
6/20	100	Black Lake	1.194	.00939	1.000	.00315
		Chignik Lake	-.194	.00939	0.000	.00315
6/24	100	Black Lake	1.233	.00930	1.000	.00313
		Chignik Lake	-.233	.00930	0.000	.00313
6/28	100	Black Lake	1.155	.00948	.985	.00322
		Chignik Lake	-.155	.00948	.015	.00322
6/30	99	Black Lake	.956	.01022	.901	.00346
		Chignik Lake	.044	.01022	.099	.00346
7/ 3	97	Black Lake	.746	.01147	.797	.00369
		Chignik Lake	.254	.01147	.203	.00369
7/ 7	100	Black Lake	.690	.01154	.586	.00415
		Chignik Lake	.310	.01154	.414	.00415
7/10	100	Black Lake	.322	.01438	.355	.00526
		Chignik Lake	.678	.01438	.645	.00526
7/14	64	Black Lake	.053	.02140	.125	.00682
		Chignik Lake	.947	.02140	.875	.00682
7/20	47	Black Lake	-.245	.02556	.018	.00522
		Chignik Lake	1.245	.02556	.982	.00522

Table 32. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1982 sockeye salmon run to Chignik.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/11	16	Black Lake	1.150	.02135		
		Chignik Lake	-.150	.02135		
6/16	15	Black Lake	.831	.03762	.817	.01057
		Chignik Lake	.169	.03762	.183	.01057
6/20	17	Black Lake	.620	.03618	.795	.01199
		Chignik Lake	.380	.03618	.205	.01199
6/24	15	Black Lake	.933	.03412	.786	.01107
		Chignik Lake	.067	.03412	.214	.01107
6/28	20	Black Lake	.805	.02937	.781	.00985
		Chignik Lake	.195	.02937	.219	.00985
6/30	25	Black Lake	.606	.02514	.637	.00829
		Chignik Lake	.394	.02514	.363	.00829
7/ 3	31	Black Lake	.501	.02011	.454	.00612
		Chignik Lake	.499	.02011	.546	.00612
7/ 7	55	Black Lake	.254	.00979	.278	.00393
		Chignik Lake	.746	.00979	.722	.00393
7/10	79	Black Lake	.080	.00546	.139	.00220
		Chignik Lake	.920	.00546	.861	.00220
7/14	100	Black Lake	.084	.00458	.057	.00155
		Chignik Lake	.916	.00458	.943	.00155
7/20	100	Black Lake	.008	.00393	.031	.00095
		Chignik Lake	.992	.00393	.969	.00095

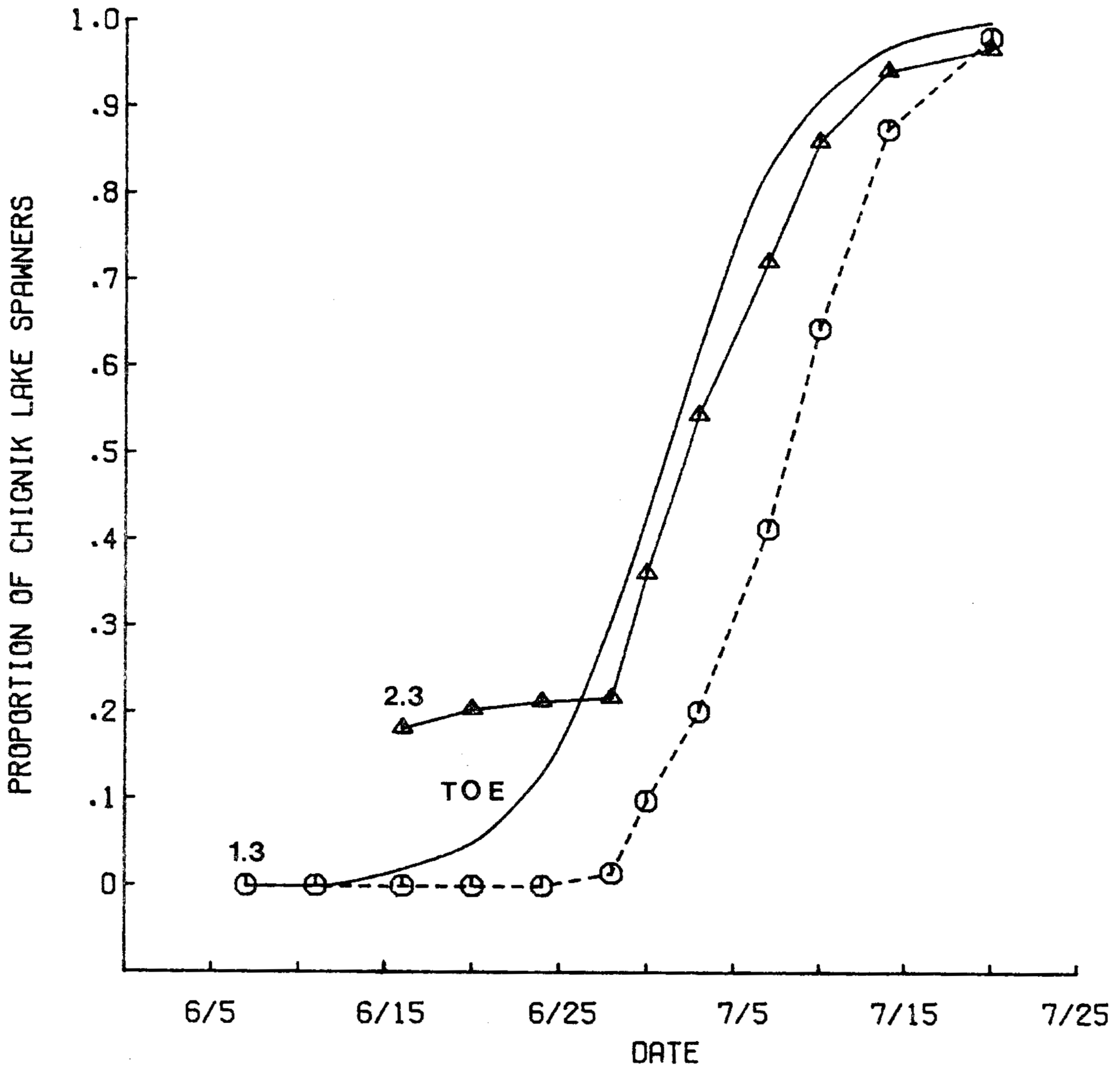

Figure 26. Daily stock composition during the period of transition for the age-specific stock composition estimates smoothed by a moving average of three sample dates. The average TOE curve (shifted five days earlier) used by ADF&G to separate the 1982 Chignik sockeye salmon run by stock is shown for comparison.

Table 33. Summary of the escapement, commercial catch, and total return by age class and stock for the 1982 Chignik sockeye salmon run estimated by analysis of scale patterns.

	Age											
	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
Black Lake												
Escapement	170	313	11,784	4,049	0	537,548	44,601	27	388	82	17,155	616,117
%	0.03	0.05	1.91	0.66	0.00	87.25	7.24	0.01	0.06	0.01	2.78	100.00
Catch	1,024	2,631	41,242	8,169	0	1,086,147	85,299	6	397	299	25,991	1,251,205
%	0.08	0.21	3.30	0.65	0.00	86.81	6.82	T[1]	0.03	0.02	2.08	100.00
Total	1,194	2,944	53,026	12,218	0	1,623,695	129,900	33	785	381	43,146	1,867,322
%	0.06	0.16	2.84	0.65	0.00	86.95	6.96	T[1]	0.04	0.02	2.31	99.99
Chignik Lake												
Escapement	303	1,978	4,350	17,325	0	53,006	139,994	1,122	622	1,726	1,185	221,601
%	0.14	0.89	1.96	7.82	0.00	23.92	63.17	0.50	0.28	0.78	0.54	100.00
Catch	1,434	3,007	9,996	34,036	0	80,109	287,723	886	1,505	3,796	3,167	425,659
%	0.34	0.71	2.35	8.00	0.00	18.82	67.59	0.21	0.35	0.89	0.74	100.00
Total	1,737	4,985	14,346	51,361	0	133,115	427,717	1,998	2,127	5,522	4,352	647,260
%	0.27	0.77	2.22	7.93	0.00	20.57	66.08	0.31	0.33	0.85	0.67	100.00

[1] Trace < 0.005%

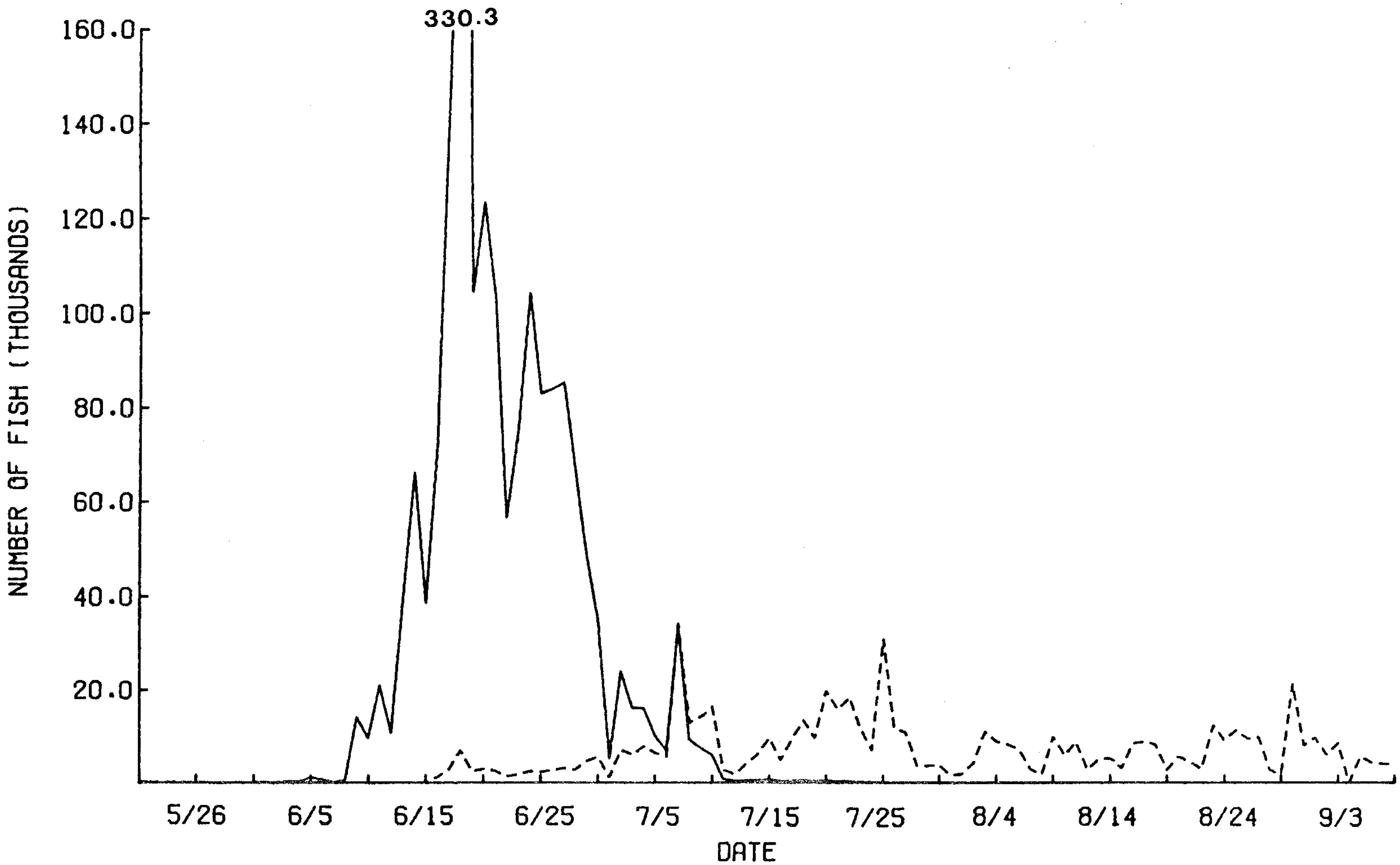

Figure 27. Total daily abundance of the Black Lake (——) and Chignik Lake (---) stocks in the 1982 Chignik sockeye salmon run.

Table 34. Total return by age class for the Black Lake stock, 1978-1982, estimated by the scale pattern analysis method.

Year	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
1978	0	333	50,713	121,029	4,588	752,716	587,019	6,752	3,190	264	0	1,526,604
%	0.00	0.02	3.32	7.93	0.30	49.31	38.45	0.44	0.21	0.02	0.00	100.00
1979	506	1,777	19,444	114,405	1,387	120,290	315,871	2,496	0	809	0	576,985
%	0.09	0.31	3.37	19.83	0.24	20.85	54.74	0.43	0.00	0.14	0.00	100.00
1980	99	85	42,633	53,609	533	69,370	295,048	1,752	112	494	2,357	466,092
%	0.02	0.02	9.15	11.50	0.11	14.88	63.30	0.38	0.02	0.11	0.51	100.00
1981	223	370	56,257	23,572	1,004	636,001	424,922	2,591	960	429	11,190	1,157,519
%	0.02	0.03	4.86	2.04	0.09	54.94	36.71	0.22	0.08	0.04	0.97	100.00
1982	1,194	2,944	53,026	12,218	0	1,623,695	129,900	33	785	381	43,146	1,867,322
%	0.06	0.16	2.84	0.65	0.00	86.95	6.96	T[1]	0.04	0.02	2.31	99.99

[1] Trace < 0.005%

Table 35. Total return by age class for the Chignik Lake stock, 1978-1982, estimated by the scale pattern analysis method.

Year	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
1978	0	2,653	18,509	166,073	29,542	54,455	689,613	13,329	94	2,728	0	976,996
%	0.00	0.27	1.90	17.00	3.02	5.57	70.59	1.36	0.01	0.28	0.00	100.00
1979	1,070	6,911	23,811	191,055	3,736	102,319	892,112	3,587	0	259	0	1,224,860
%	0.09	0.57	1.94	15.60	0.31	8.35	72.83	0.29	0.00	0.02	0.00	100.00
1980	252	807	59,291	185,502	2,037	123,709	678,022	4,759	51	1,249	2,705	1,058,384
%	0.02	0.08	5.60	17.53	0.19	11.69	64.06	0.45	T[1]	0.12	0.26	100.00
1981	416	3,918	52,041	92,999	3,522	764,753	847,360	9,130	901	2,283	7,500	1,784,823
%	0.02	0.22	2.91	5.21	0.20	42.85	47.48	0.51	0.05	0.13	0.42	100.00
1982	1,737	4,985	14,346	51,361	0	133,115	427,717	1,998	2,127	5,522	4,352	647,260
%	0.27	0.77	2.22	7.93	0.00	20.57	66.08	0.31	0.33	0.85	0.67	100.00

[1] Trace < 0.005%

annular zone the set of mean scale growth characters test in previous Hotelling T^2 analyses were compared. Significant differences between the standards were found in three of the four tests of the first lacustrine annular zone and in two of the tests of the second lacustrine annular zone (Table 36). Roy-Bose simultaneous 95.0% confidence intervals indicated that, with one exception, there was a significant difference in the mean number of circuli in the annular zone for the 2.2 and 2.3 Chignik Lake standards which were different. In two of the tests the mean width of the annular zone was significantly different, also. In only one test was a significant difference found in the mean scale growth within a lacustrine annular zone.

Although there were often significant differences between the 2.3 Chignik Lake standards and their representative 2.2 standards for the characters reflecting the total scale growth of an annular zone, the growth within the annular zones, specifically the mean distance to each of the first five circuli in each annular zone, was usually not significantly different. For each set of 2.2-2.3 Chignik Lake standards, the mean scale growth to each of the first six circuli in each lacustrine annular zone is shown, and compared to the mean growth for the corresponding 2.3 Black Lake standard, in Figures 28a-d. The mean scale growth within each lacustrine annular zone was usually very similar for each of the Chignik Lake 2.2-2.3 comparisons.

Evaluation of a Year's Pooled Standard

A year's pooled Chignik Lake standard could be established for both the 1.3 and 2.3 age classes. The hypothesis of identical mean scale growth during the years 1978-1982 was tested by multivariate analysis of variance. The MANOVA comparing the mean scale character vectors of the 1.3 age class for the Chignik Lake stock in the years 1978-1982 was highly significant (Table 37). The mean scale growth in these years was similar except in 1980 when the mean scale growth was much larger than the other years (Figure 29). To test whether the mean scale growth in 1980 was responsible for the significance of the MANOVA, the 1980 data were removed and the analysis repeated. Although the significance of the test was reduced, it was still highly significant (Table 37). The characters reflecting the total scale growth of the lacustrine annular zone might be responsible for the significance of the MANOVA as they were in the 2.2-2.3 Chignik Lake standard comparisons. This hypothesis was tested by including only the mean distance to each of the first five circuli in the annular zone in the vectors being compared. For the reduced scale character vectors, a MANOVA of the two previously defined data sets was repeated. The hypothesis of equal mean scale growth was again rejected in both analyses (Table 37).

A separate MANOVA was performed for each lacustrine annular zone of the 2.3 Chignik Lake standards. For the first analysis of each annular zone, the mean scale character vectors included the mean number of circuli and mean width of the zone. A second MANOVA was performed which compared the mean scale character vectors with these two characters omitted. The hypothesis of identical mean scale growth for the 1978-1982 2.3 Chignik Lake standards was rejected in both zones for all tests (Table 38). The mean scale growth in the first lacustrine annular zone varied considerably for the years examined (Figure 30a). The mean scale growth in the second lacustrine annular zone did not vary as much except for the 1982 growth which was much greater than the others (Figure 30b).

Table 36. Results of Hotelling's test for the equality of the mean scale growth vectors of the first and second lacustrine annular zones for each set of 2.2-2.3 Chignik Lake standards. The results of Box's test for the equality of covariance matrices are reported, also. (NS = not significant, SIGN = significant $\alpha \leq 0.05$).

Standard	Age	Sample size	Box's test	Hotelling's test	Significant characters
First lacustrine annular zone					
1978 CL	2.2	90	SIGN	NS	
1979 CL	2.3	77			
1979 CL	2.2	194	SIGN	SIGN	number circuli,
1980 CL	2.3	200			width zone
1980 CL	2.2	140	NS	SIGN	number circuli
1981 CL	2.3	188			
1981 CL	2.2	146	SIGN	SIGN	number circuli
1982 CL	2.3	195			
Second lacustrine annular zone					
1978 CL	2.2	128	NS	SIGN	end 1st FW AZ
1979 CL	2.3	199			to C3 2nd FW AZ
1979 CL	2.2	200	NS	SIGN	number circuli,
1980 CL	2.3	200			width zone
1980 CL	2.2	149	SIGN	NS	
1981 CL	2.3	191			
1981 CL	2.2	159	NS	NS	
1982 CL	2.3	200			

CL = Chignik Lake

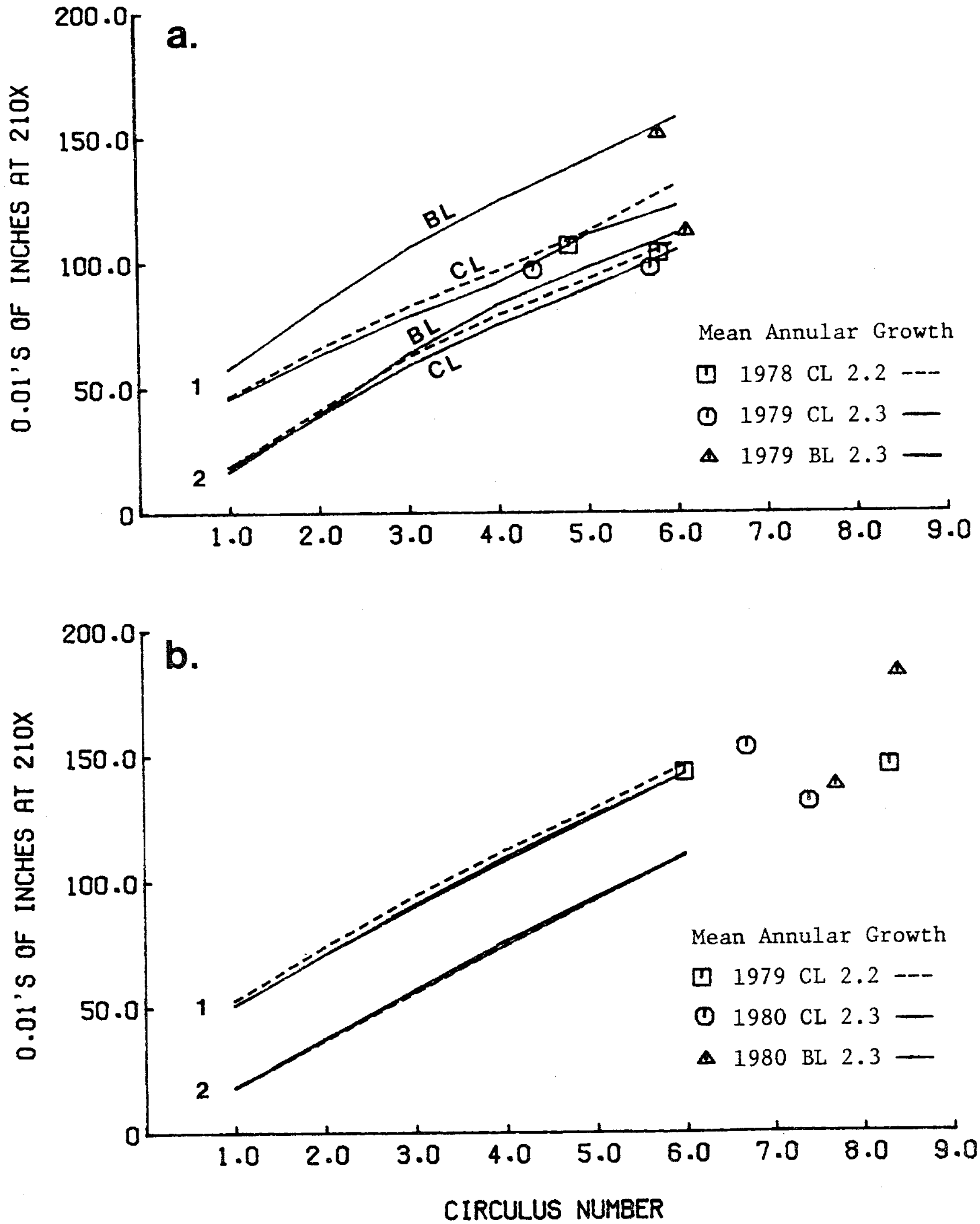

Figure 28. Mean scale growth in the first (1) and second (2) lacustrine annular zones for the 1979 (a), 1980 (b), 1981 (c), and 1982 (d) age 2.3 Black Lake and Chignik Lake standards for the previous year's age 2.2 Chignik Lake standard (continued).

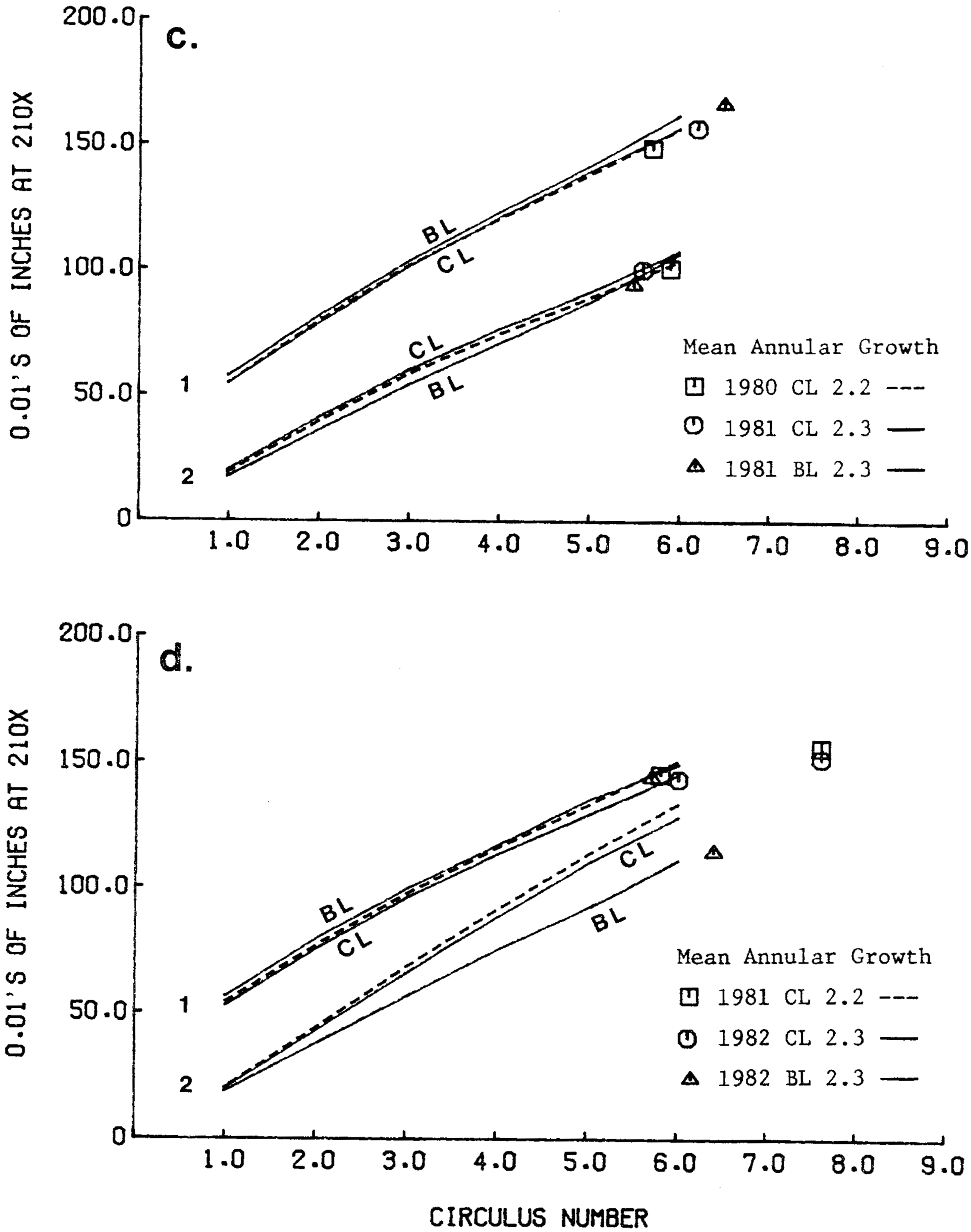

Figure 28. Mean scale growth in the first (1) and second (2) lacustrine annular zones for the 1979 (a), 1980 (b), 1981 (c), and 1982 (d) age 2.3 Black Lake and Chignik Lake standards and for the previous year's age 2.2 Chignik Lake standard (continued).

Table 37. Results of the multivariate analysis of variance of the mean scale growth characters for the 1.3 Chignik Lake standards, 1978-1982.

Years compared	Scale characters	F-statistic	Significance
1978-1982	all[1]	2.53	<0.001
1978,1979, 1981,1982	all	2.13	0.002
1978-1982	within annular zone only[2]	2.71	<0.001
1978,1979, 1981,1982	within annular zone only	2.07	0.010

[1] Mean number circuli first lacustrine annular zone, width first lacustrine annular zone, mean distance to each of the first 5 circuli in the annular zone.

[2] Mean distance to each of the first 5 circuli in the first lacustrine annular zone only.

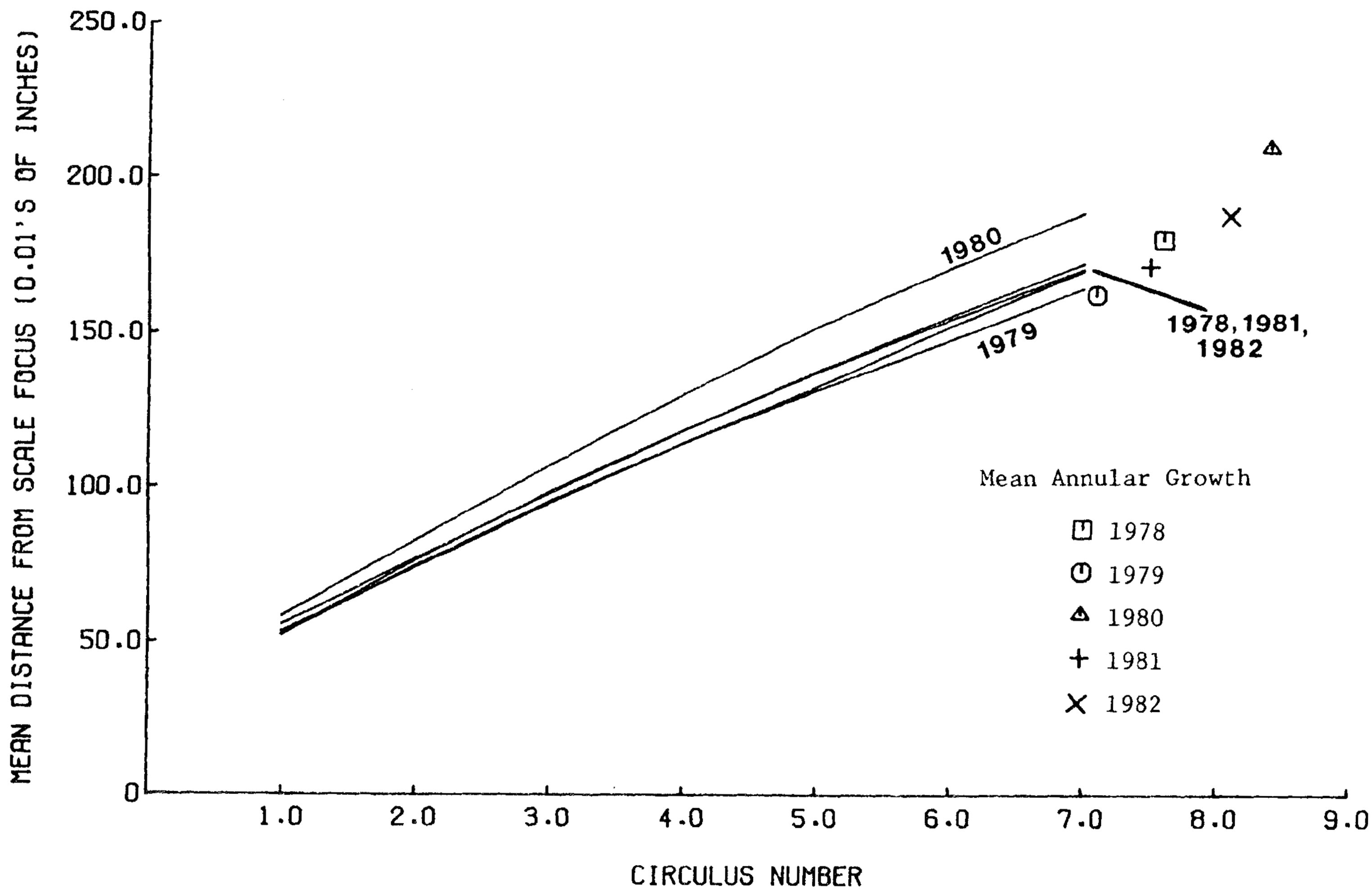

Figure 29. Mean scale growth in the first lacustrine annular zone for the age 1.3 Chignik Lake standards, 1978-1982.

Table 38. Results of the multivariate analysis of variance of the mean scale growth characters for the 2.3 Chignik Lake standards, 1978-1982.

Years compared	Scale characters	F-statistic	Significance
First lacustrine annular zone			
1978-1982	all[1]	39.39	<0.001
1978-1982	within annular zone only[2]	33.55	<0.001
Second lacustrine annular zone			
1978-1982	all	40.25	<0.001
1978-1982	within annular zone only	26.60	<0.001

[1] Mean number circuli in the lacustrine annular zone, width of the lacustrine annular zone, mean distance to each of the first 5 circuli in the annular zone.

[2] Mean distance to each of the first 5 circuli in the lacustrine annular zone only.

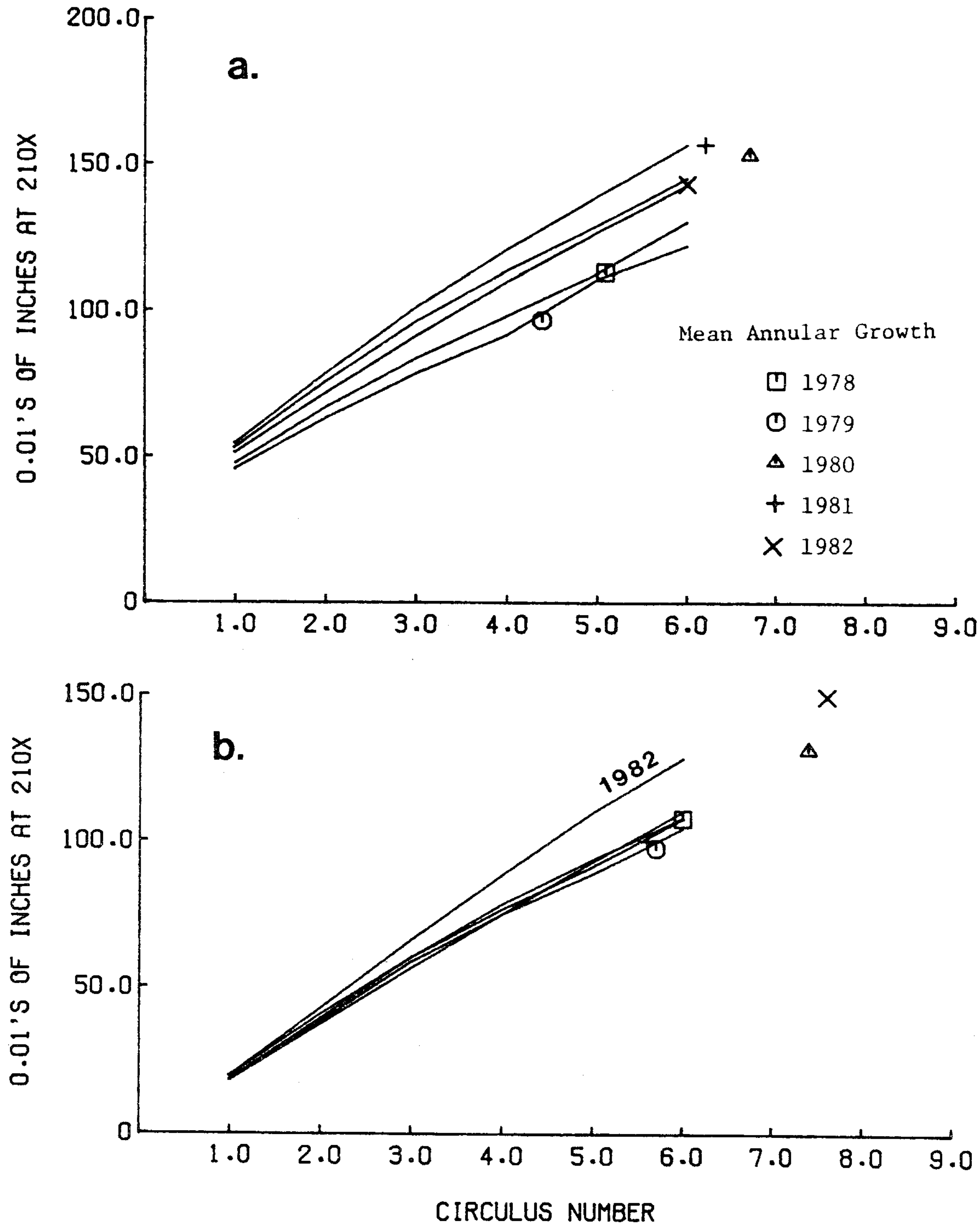

Figure 30. Mean scale growth in the first (a) and second (b) lacustrine annular zones for the age 2.3 Chignik Lake standards, 1978-1982.

In-season Stock Separation Simulations for 1979-1981

In-season stock separation analyses were simulated for each of the years 1979-1981. From the previous analyses, it was apparent that pooling either the 1.3 or 2.3 standards to form a universal Chignik Lake standard for that age class was not appropriate. A satisfactory universal standard was not possible because of the large variation in mean scale growth patterns during the years 1978-1982. Although the universal standard might adequately represent the actual Chignik Lake standard in some years, in most years it would not. For an actual in-season separation, there would be no prior knowledge whether the universal standard was representative of the actual Chignik Lake standard, therefore it was not considered to be a satisfactory solution.

The mean scale growth of one year's 2.2 Chignik Lake standard and the next year's 2.3 Chignik Lake standard was found to be very similar in all four 2.2-2.3 comparisons. Within each lacustrine annular zone, the mean distance to each of the first five circuli in the zone was not significantly different except for one 2.2-2.3 comparison. The mean scale growth within the first five circuli of each lacustrine annular zone was similar; therefore, the previous year's 2.2 Chignik Lake standard was selected to represent the 2.3 standard for in-season linear discriminant function analysis of the 2.3 age class.

Only those scale characters which were within the zone of similar lacustrine growth were screened for the in-season analyses. Characters reflecting the total growth of a lacustrine annular zone were omitted. No significant differences were detected in the 2.2-2.3 standard comparisons for the scale characters screened for the in-season analyses (Appendix Table 8). The scale characters for each in-season 2.3 LDF analysis were selected from this subset by the stepwise F procedure described for the post-season analyses.

The post-season procedure to estimate the number of each stock present in the catch or escapement on a particular day was applied to the daily escapements for the in-season analyses. Unlike the post-season procedure, which always had age-specific stock composition estimates for the 1.3 and 2.3 age classes and in 1979 and 1980 the 2.2 age class, the in-season analysis had estimates only for the 2.3 age class. The stock composition estimates for the 2.3 age class were applied to all age classes present. Only the number of each stock present in the daily escapement is required for the in-season analysis because management decisions for the commercial fishery are based upon the cumulative escapement totals for each stock. The age composition of each stock is not required for in-season purposes.

1979:

The linear discriminant function for estimating the stock composition in the 1979 in-season simulation was established with the 1979 2.3 Black Lake standard and the 1978 2.2 Chignik Lake standard. The in-season LDF for the 2.3 age class separated the stocks with 90.5% accuracy (Table 39) which was only 3% less than the accuracy of the post-season LDF for that age class. Table 40 summarizes the scale characters selected for the in-season LDF.

All age 2.3 samples of unknown stock composition which were collected in Chignik Lagoon in 1979 were classified with the in-season LDF and the adjusted and smoothed

Table 39. Classification matrix for age 2.3 sockeye salmon in the 1979 in-season simulation.

Age 2.3		
Classified stock of origin	Actual stock of origin	
	Black Lake	Chignik Lake
Black Lake	0.880	0.070
Chignik Lake	0.120	0.930
Sample size	200	129

Mean classification = 0.905

Table 40. Scale characters selected for the final discriminant function used to classify the 2.3 age class in the 1979 in-season simulation. (C = circulus, FW = freshwater, AZ = annular zone)[1].

Scale characters selected	1979 2.3 Black Lake $\bar{x}$	s	1978 2.2 Chignik Lake $\bar{x}$	s
1. distance focus to C1, 1st FW AZ	57.9	6.0	46.9	5.3
2. distance C2 to C3, 1st FW AZ	22.9	4.6	16.6	3.6
3. distance C2 to C4, 2nd FW AZ	44.0	7.8	38.0	6.7
4. distance C3 to C4, 1st FW AZ	18.8	3.9	14.2	3.5
5. relative size, distance C3 to C4 1st FW AZ	0.12	0.02	0.13	0.03
Sample size	200		129	
Equality of covariance matrices, significant $\alpha \leq 0.01$				

[1] All linear distances reported in 0.01's of inches at 210X.

stock composition estimates calculated (Table 41). The smoothed stock composition estimates for the in-season analysis were very similar to those for the post-season analysis (Figure 31). When the in-season estimates were applied to the escapement, the total Black Lake escapement through 25 July was estimated as 381,405 fish. For comparison, the post-season estimate of the Black Lake escapement was 385,694. The cumulative Black Lake and Chignik Lake escapements estimated by the in-season and post-season analyses are compared in Figure 32.

The major premise of the in-season analyses is that, for the scale characters examined, one year's 2.2 Chignik Lake standard provides an adequate representation of the next year's 2.3 Chignik Lake standard. This premise can be evaluated by classifying the actual 2.3 Chignik Lake standard with the in-season LDF. The percentage correctly classified as belonging to the Chignik Lake stock will indicate how well the in-season Chignik Lake standard represents the actual standard for that year. For the 1979 in-season simulation, the 1979 2.3 Chignik Lake standard was classified with the in-season LDF. The adjusted percentage of the standard classified as Chignik Lake stock was 100.0%.

1980:

The standards for the 1980 in-season LDF were the 1980 2.3 Black Lake standard and the 1979 2.2 Chignik Lake standard. The mean classification accuracy of the in-season LDF for the 2.3 age class was 88.4% (Table 42). This was better than the classification accuracy for the 2.3 age class in the post-season analysis (83.8%). The six scale characters selected for the in-season analysis are summarized in Table 43.

The smoothed in-season stock composition estimates of the proportion of the Chignik Lake stock present in the 2.3 age class (Table 44) were consistently less than the post-season estimates by about 20% (Figure 33). When the 1980 2.3 Chignik Lake standard was classified by the in-season LDF only 69.0% of the sample was correctly assigned to the Chignik Lake stock. The large discrepancy between the in-season and post-season stock composition estimates caused a significant difference in the cumulative escapement estimates for each stock (Figure 34). The in-season estimate of the total Black Lake escapement was 463,450 while the post-season analysis allocated only 311,332 fish to the escapement.

1981:

The 1981 in-season LDF was constructed with the 1980 2.2 Chignik Lake standard and the 1981 2.3 Black Lake standard. The mean classification accuracy of the in-season LDF was only 66.5% (Table 45). For the post-season analysis of the 2.3 age class the mean classification accuracy was 79.6%. Table 46 summarizes the scale characters selected for the in-season analysis. When the 1981 2.3 Chignik Lake standard was classified with the in-season LDF, 83.5% of the sample was correctly assigned to the Chignik Lake stock. This indicates that the in-season Chignik Lake standard was a good representation of the actual standard.

The smoothed stock composition estimates for the 2.3 in-season analysis (Table 47) are compared to the post-season estimates in Figure 35. A total of 448,857 fish were assigned to the Black Lake escapement by the in-season simulation. The post-season estimate of the total Black Lake escapement was 438,540 (Figure 36).

Table 41. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1979 in-season simulation.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 6	33	Black Lake	.774	.01028	.883	.00157
		Chignik Lake	.226	.01028	.117	.00157
6/ 9	81	Black Lake	.874	.00388	.867	.00205
		Chignik Lake	.126	.00388	.133	.00205
6/16	57	Black Lake	.953	.00429	.858	.00177
		Chignik Lake	.047	.00429	.142	.00177
6/27	46	Black Lake	.746	.00778	.647	.00176
		Chignik Lake	.254	.00778	.353	.00176
7/ 3	90	Black Lake	.243	.00380	.416	.00168
		Chignik Lake	.757	.00380	.584	.00168
7/ 7	100	Black Lake	.259	.00355	.217	.00114
		Chignik Lake	.741	.00355	.783	.00114
7/ 8	100	Black Lake	.148	.00292	.169	.00101
		Chignik Lake	.852	.00292	.831	.00101
7/13	100	Black Lake	.099	.00258	.091	.00083
		Chignik Lake	.901	.00258	.909	.00083
7/16	100	Black Lake	.025	.00198	.062	.00076
		Chignik Lake	.975	.00198	.938	.00076
7/18	100	Black Lake	.062	.00229	.070	.00078
		Chignik Lake	.938	.00229	.930	.00078
7/20	100	Black Lake	.123	.00275	.111	.00088
		Chignik Lake	.877	.00275	.889	.00088
7/22	100	Black Lake	.148	.00292	.090	.00063
		Chignik Lake	.852	.00292	.910	.00063

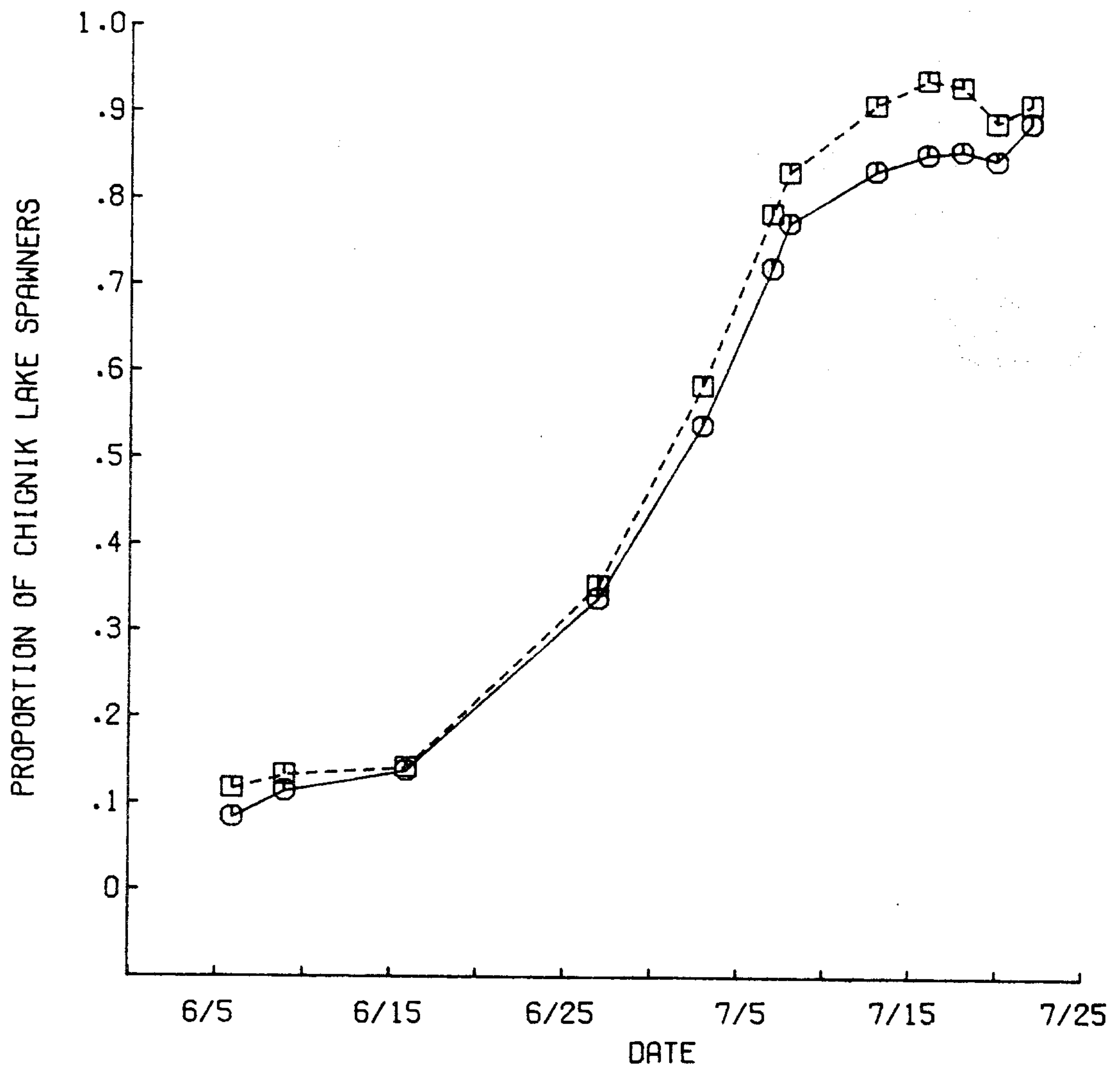

Figure 31. Comparison of the stock composition estimates for the 2.3 age class by the post-season (——) and in-season (---) analyses of the 1979 Chignik sockeye salmon run.

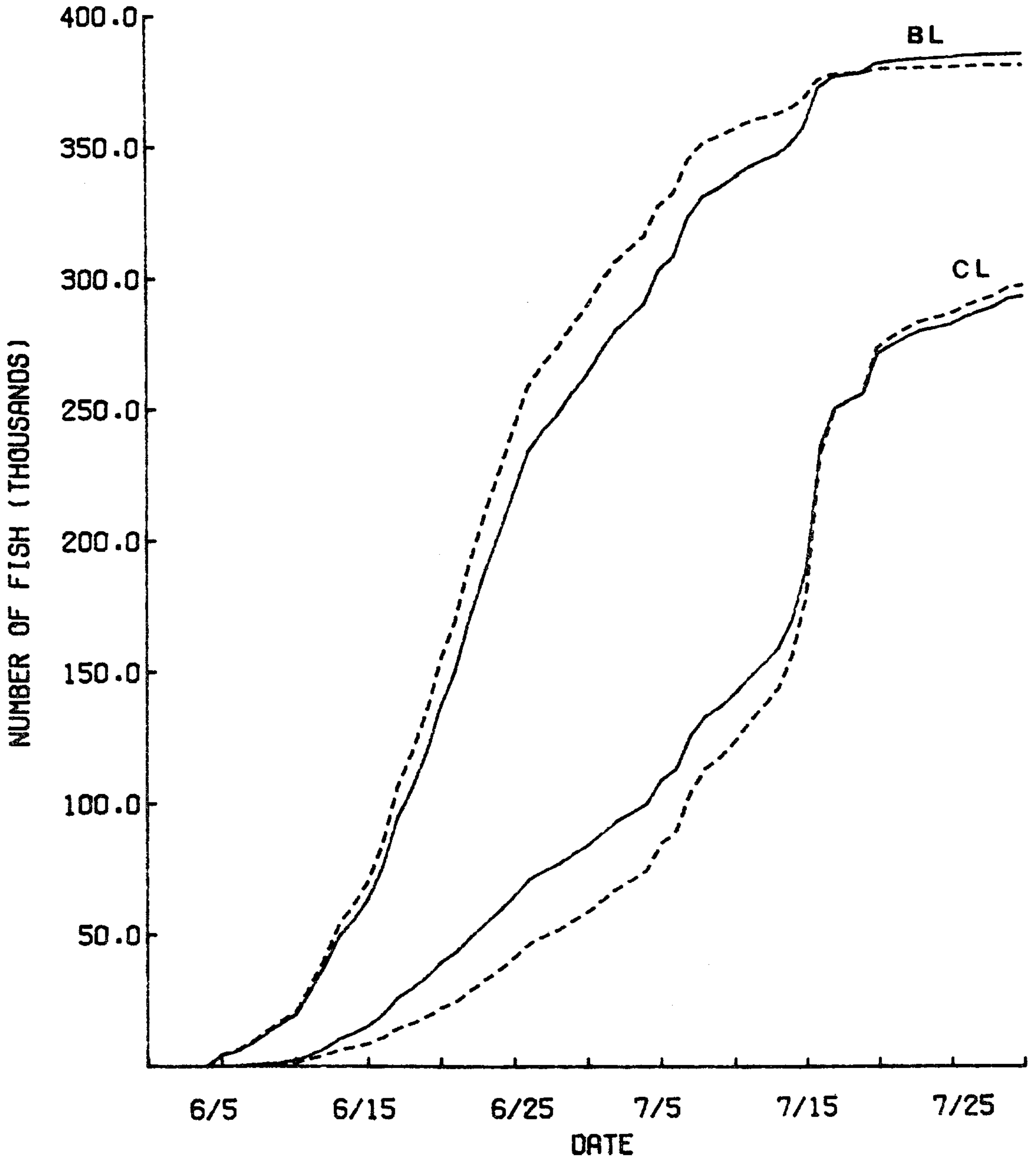

Figure 32. Comparison of the cumulative Black Lake and Chignik Lake escapement estimates by the post-season (——) and in-season (---) analyses of the 1979 Chignik sockeye salmon run.

Table 42. Classification matrix for age 2.3 sockeye salmon in the 1980 in-season simulation.

Age 2.3 Classified stock of origin	Actual stock of origin Black Lake	 Chignik Lake
Black Lake	0.840	0.072
Chignik Lake	0.160	0.928
Sample size	200	194
	Mean classification = 0.884	

Table 43. Scale characters selected for the final discriminant function used to classify the 2.3 age class in the 1980 in-season simulation. (C = circulus, FW = freshwater, AZ = annular zone)[1].

Scale characters selected	1980 2.3 Black Lake $\bar{x}$	s	1979 2.2 Chignik Lake $\bar{x}$	s
1. relative size, distance C3 to C4 1st FW AZ	0.10	0.02	0.13	0.02
2. distance C3 to C4, 1st FW AZ	18.1	4.1	18.1	3.6
3. distance focus to C5, 1st FW AZ	126.1	13.9	129.4	11.8
4. relative size, distance 1st C before end of 1st FW AZ to end of zone	0.09	0.02	0.09	0.02
5. distance C1 to C5, 1st FW AZ	74.7	11.0	76.3	10.2
6. distance C2 to C3, 1st FW AZ	18.9	4.1	20.2	3.9
Sample size	200		194	
Equality of covariance matrices, significant $\alpha \leq 0.01$				

[1] All linear distances reported in 0.01's of inches at 210X.

Table 44. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1980 in-season simulation.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 6	23	Black Lake	.925	.01352	.967	.00223
		Chignik Lake	.075	.01352	.033	.00223
6/ 8	45	Black Lake	.977	.00659	.967	.00289
		Chignik Lake	.023	.00659	.033	.00289
6/11	43	Black Lake	1.027	.00594	.992	.00203
		Chignik Lake	-.027	.00594	.008	.00203
6/13	50	Black Lake	1.000	.00570	1.000	.00180
		Chignik Lake	0.000	.00570	0.000	.00180
6/17	44	Black Lake	1.090	.00454	1.000	.00174
		Chignik Lake	-.090	.00454	0.000	.00174
6/23	49	Black Lake	1.022	.00543	.920	.00188
		Chignik Lake	-.022	.00543	.080	.00188
7/ 1	61	Black Lake	.760	.00697	.764	.00207
		Chignik Lake	.240	.00697	.236	.00207
7/ 5	73	Black Lake	.531	.00625	.625	.00199
		Chignik Lake	.469	.00625	.375	.00199
7/10	100	Black Lake	.583	.00472	.574	.00174
		Chignik Lake	.417	.00472	.426	.00174
7/11	100	Black Lake	.609	.00472	.531	.00154
		Chignik Lake	.391	.00472	.469	.00154
7/13	100	Black Lake	.401	.00439	.449	.00147
		Chignik Lake	.599	.00439	.551	.00147
7/15	100	Black Lake	.336	.00413	.358	.00141
		Chignik Lake	.664	.00413	.642	.00141
7/17	100	Black Lake	.336	.00413	.293	.00130
		Chignik Lake	.664	.00413	.707	.00130
7/19	100	Black Lake	.206	.00342	.319	.00133
		Chignik Lake	.794	.00342	.681	.00133
7/21	100	Black Lake	.414	.00443	.349	.00137
		Chignik Lake	.586	.00443	.651	.00137
7/23	100	Black Lake	.427	.00447	.280	.00099
		Chignik Lake	.573	.00447	.720	.00099

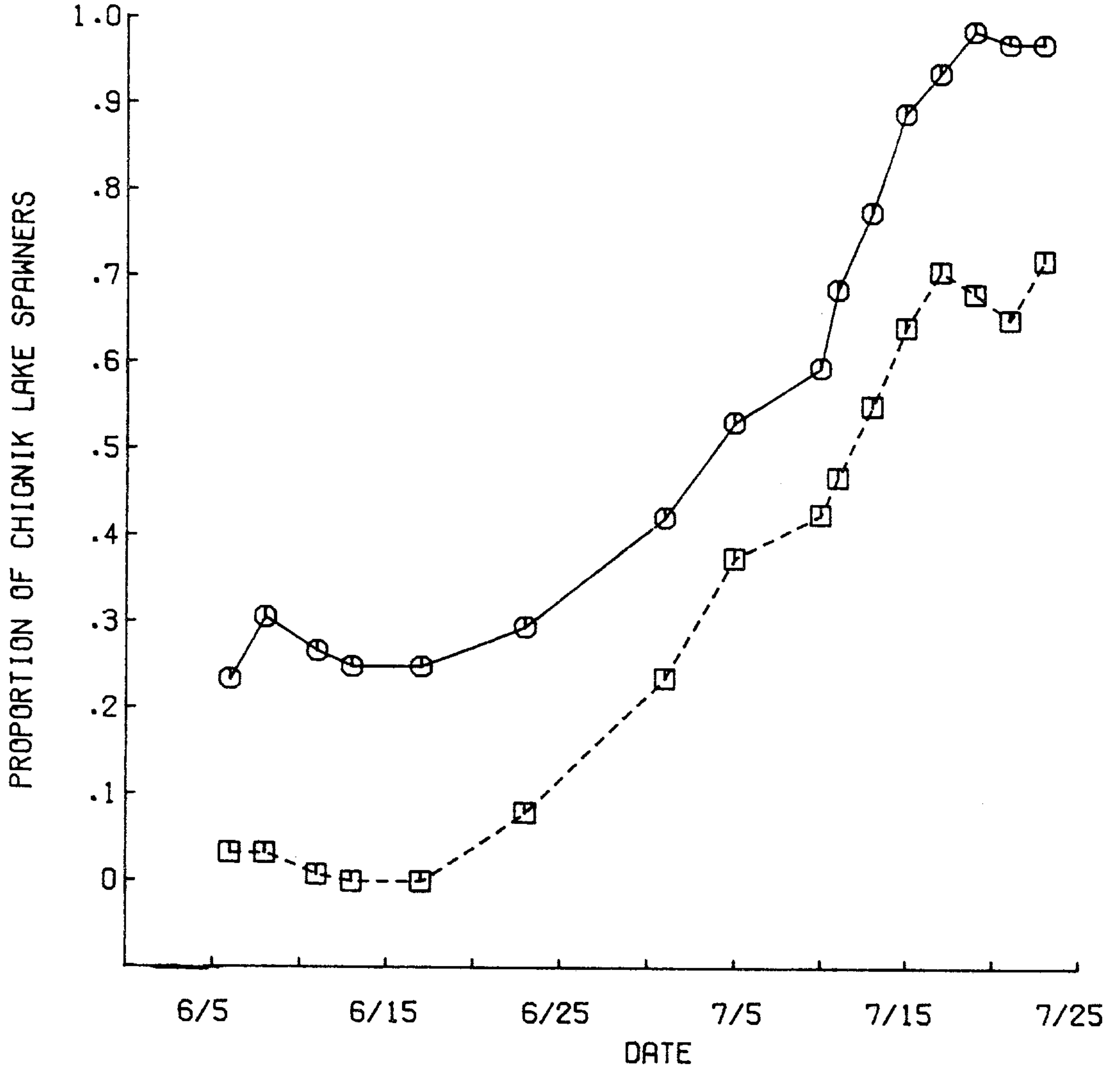

Figure 33. Comparison of the stock composition estimates for the 2.3 age class by the post-season (——) and in-season (---) analyses of the 1980 Chignik sockeye salmon run.

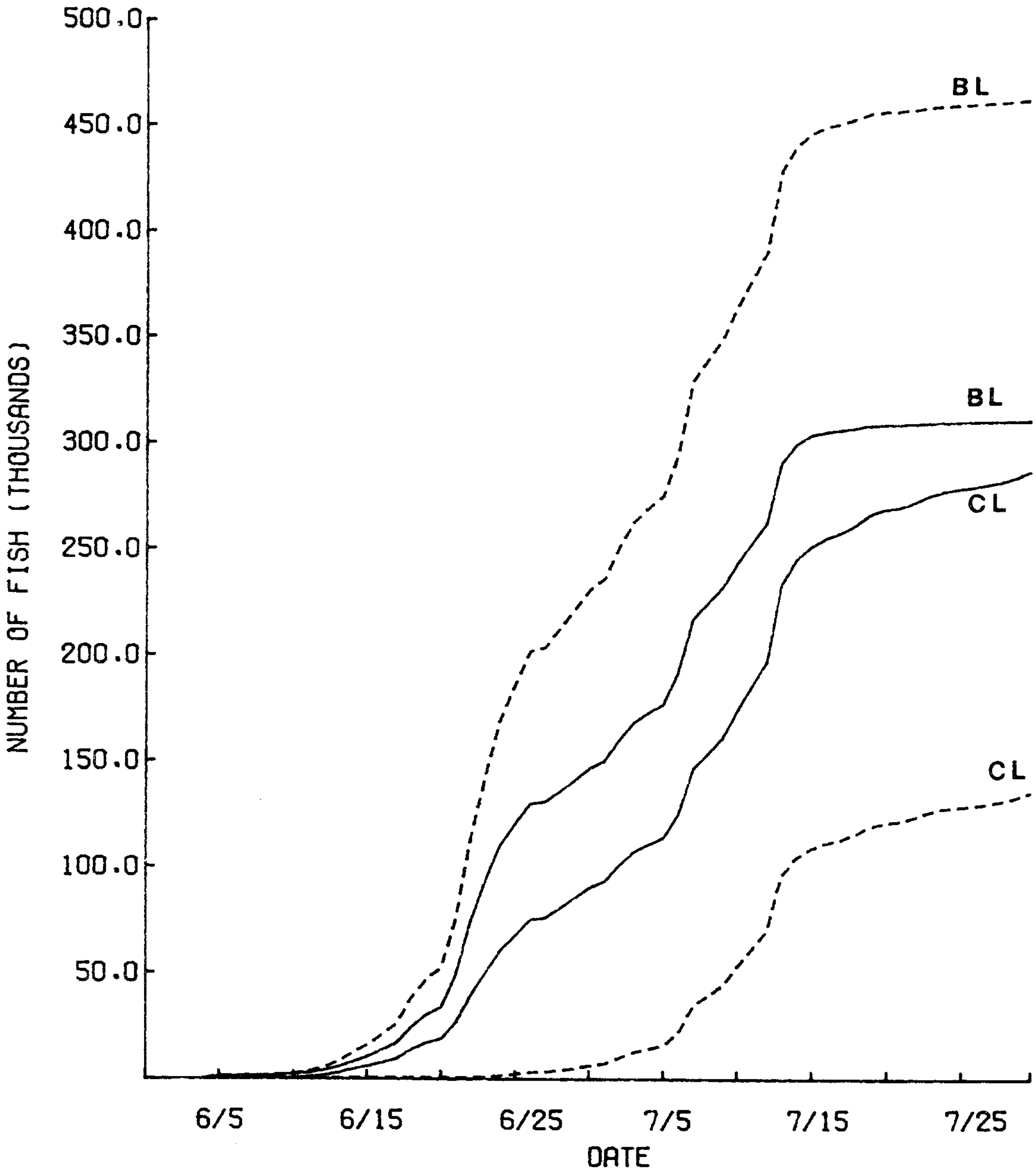

Figure 34. Comparison of the cumulative Black Lake and Chignik Lake escapement estimates by the post-season (——) and in-season (---) analyses of the 1980 Chignik sockeye salmon run.

Table 45. Classification matrix for age 2.3 sockeye salmon in the 1981 in-season simulation.

Age 2.3		
Classified stock of origin	Actual stock of origin	
	Black Lake	Chignik Lake
Black Lake	0.614	0.285
Chignik Lake	0.386	0.715
Sample size	140	151
	Mean classification = 0.665	

Table 46. Scale characters selected for the final discriminant function used to classify the 2.3 age class in the 1981 in-season simulation. (C = circulus, FW = freshwater, AZ = annular zone)[1].

Scale characters selected	1981 2.3 Black Lake $\bar{x}$	s	1980 2.2 Chignik Lake $\bar{x}$	s
1. distance end of 1st FW AZ to C1 2nd FW AZ	17.3	4.0	19.1	3.8
2. distance focus to C1, 1st FW AZ	57.7	7.4	54.9	5.1
3. 1st C widest pair in 1st FW AZ	1.8	1.1	1.4	0.6
Sample size	140		151	
Equality of covariance matrices, significant $\alpha \leq 0.01$				

[1] All linear distances reported in 0.01's of inches at 210X.

Table 47. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1981 in-season simulation.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 3	18	Black Lake	.991	.13734	.881	.02604
		Chignik Lake	.009	.13734	.119	.02604
6/ 8	26	Black Lake	.653	.09701	.665	.03388
		Chignik Lake	.347	.09701	.335	.03388
6/11	35	Black Lake	.350	.07054	.538	.02680
		Chignik Lake	.650	.07054	.462	.02680
6/15	35	Black Lake	.610	.07365	.573	.02304
		Chignik Lake	.390	.07365	.427	.02304
6/17	43	Black Lake	.760	.06319	.526	.02075
		Chignik Lake	.240	.06319	.474	.02075
6/19	51	Black Lake	.207	.04989	.459	.01834
		Chignik Lake	.793	.04989	.541	.01834
6/22	50	Black Lake	.410	.05198	.496	.01592
		Chignik Lake	.590	.05198	.504	.01592
6/24	77	Black Lake	.871	.04145	.427	.01392
		Chignik Lake	.129	.04145	.573	.01392
6/28	100	Black Lake	-.046	.03187	.447	.01145
		Chignik Lake	1.046	.03187	.553	.01145
7/ 1	100	Black Lake	.471	.02972	.162	.01030
		Chignik Lake	.529	.02972	.838	.01030
7/ 3	100	Black Lake	.015	.03112	.177	.01018
		Chignik Lake	.985	.03112	.823	.01018
7/ 6	100	Black Lake	.046	.03079	.106	.01015
		Chignik Lake	.954	.03079	.894	.01015
7/ 9	100	Black Lake	.258	.02944	.177	.00997
		Chignik Lake	.742	.02944	.823	.00997
7/12	100	Black Lake	.228	.02953	.248	.00982
		Chignik Lake	.772	.02953	.752	.00982
7/21	100	Black Lake	.258	.02944	.162	.00655
		Chignik Lake	.742	.02944	.838	.00655

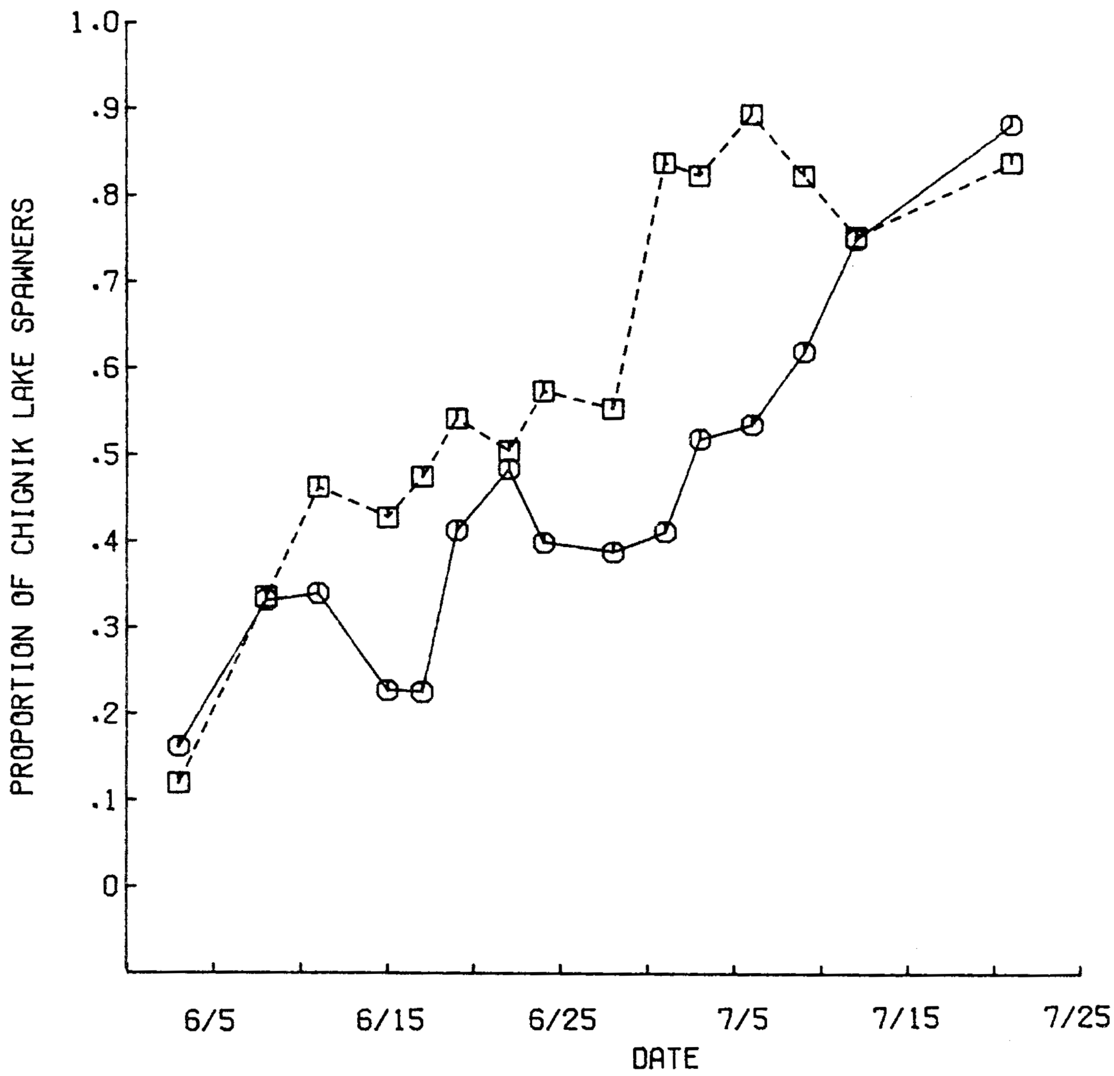

Figure 35. Comparison of the stock composition estimates for the 2.3 age class by the post-season (——) and in-season (---) analyses of the 1981 Chignik sockeye salmon run.

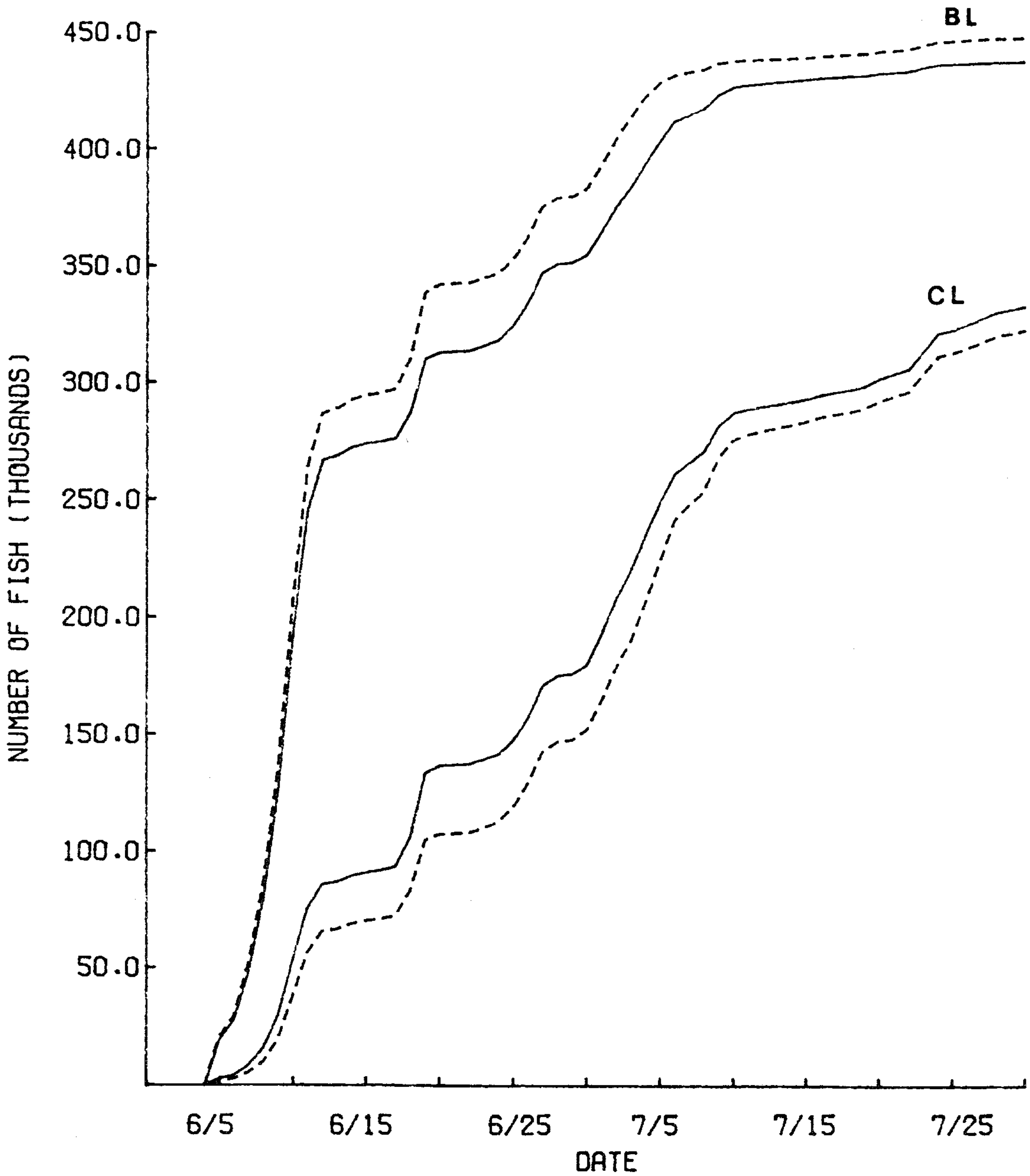

Figure 36. Comparison of the cumulative Black Lake and Chignik Lake escapement estimates by the post-season (——) and in-season (---) analyses of the 1981 Chignik sockeye salmon run.

1982 In-season Stock Separation

In 1982, an in-season stock separation analysis was conducted at Chignik during the main portion of the sockeye salmon run in June and July. A digitizing system and microcomputer at the FRI field station at the outlet of Chignik Lake were used to perform the in-season analysis. It was important to process the scale samples of unknown stock composition collected in Chignik Lagoon as quickly as possible for the in-season analysis. Usually the samples were aged, measured, and analyzed within twenty-four hours of collection. The stock composition estimates were then applied to the daily escapements and the cumulative escapement of each stock estimated.

The linear discriminant function for the 1982 in-season analysis was established with scale samples collected at the outlet of Black Lake during the season and the 1981 age 2.2 Chignik Lake standard. The in-season LDF for the 2.3 age class separated the stocks with 77.7% accuracy (Table 48). For the post-season analysis of the 2.3 age class, the classification accuracy was 82.6%. The scale characters selected for the 1982 in-season LDF are summarized in Table 49.

The smoothed in-season stock composition estimates of the proportion of the Chignik Lake stock present in the 2.3 age class (Table 50) were very similar to the smoothed post-season estimates (Figure 37). A total of 620,382 fish were allocated to the Black Lake escapement by the in-season analysis. The post-season estimate for the total Black Lake escapement was 616,117. The cumulative return of each stock estimated by the post-season and in-season analyses are compared in Figure 38.

When the 1982 age 2.3 Chignik Lake standard was classified with the in-season LDF, the adjusted estimate of the percentage of the Chignik Lake stock present was 85.0%. This indicates that the in-season standard was a good representation of the actual Chignik Lake standard.

DISCUSSION

The principal objective of this report was to determine whether the two sockeye salmon stocks of the Chignik lakes could be accurately identified by their scale patterns. The contribution of each stock to the Chignik runs in the years 1978-1982 was estimated by linear discriminant function analysis of the lacustrine scale patterns of the dominant age classes in each run. Although the performance of this stock separation technique varied by age class and year, all classification accuracies of the discriminant functions were considerably better than random allocation (50.0%). Mean accuracies for the major age classes were: 85.4% for the 2.2 age class; 74.9% for the 1.3 age class; and 85.8% for the 2.3 age class (Table 51). The accuracies of the post-season analyses demonstrated that significant differences in the lacustrine scale patterns of the Black Lake and Chignik Lake stocks were present annually. Therefore, the scale pattern analysis method of separating the Chignik sockeye salmon run by stock is an alternative to the current method of separating the stocks by the average TOE curve. In the following sections the two methods of separating the Chignik sockeye salmon stocks are compared.

Table 48. Classification matrix for age 2.3 sockeye salmon in the 1982 in-season stock separation analysis.

Age 2.3 Classified stock of origin	Actual stock of origin Black Lake	 Chignik Lake
Black Lake	0.735	0.182
Chignik Lake	0.265	0.818
Sample size	102	159
	Mean classification = 0.777	

Table 49. Scale characters selected for the final discriminant function used to classify the 2.3 age class in the 1982 in-season stock separation analysis. (C = circulus, FW = freshwater, AZ = annular zone)[1].

Scale characters selected	1982 2.3 Black Lake $\bar{x}$	s	1981 2.2 Chignik Lake $\bar{x}$	s
1. distance C2 to C4, 2nd FW AZ	37.7	8.7	47.5	7.2
2. distance end of 1st FW AZ to C1 2nd FW AZ	18.6	3.9	20.4	3.9
3. relative size, distance C3 to C4 1st FW AZ	0.12	0.02	0.13	0.02
Sample size	102		159	
Equality of variance matrices, significant $\alpha \leq 0.01$				

[1] All distances reported in 0.01's of inches at 210X.

Table 50. Stock composition estimates for the scale pattern analysis of the 2.3 age class in the 1982 in-season stock separation.

Sample Date	N	Stock	Adjusted Estimate	Estimated Variance	Smoothed Estimate	Estimated Variance
6/ 7	16	Black Lake	1.120	.02746	1.000	.00610
		Chignik Lake	-.120	.02746	0.000	.00610
6/11	16	Black Lake	1.120	.02746	1.000	.00908
		Chignik Lake	-.120	.02746	0.000	.00908
6/16	15	Black Lake	1.038	.02678	.973	.01093
		Chignik Lake	-.038	.02678	.027	.01093
6/20	17	Black Lake	.918	.04410	.969	.01174
		Chignik Lake	.082	.04410	.031	.01174
6/24	15	Black Lake	.990	.03482	.962	.01190
		Chignik Lake	.010	.03482	.038	.01190
6/28	20	Black Lake	.979	.02816	.952	.00997
		Chignik Lake	.021	.02816	.048	.00997
6/30	25	Black Lake	.887	.02678	.798	.00920
		Chignik Lake	.113	.02678	.202	.00920
7/ 3	31	Black Lake	.529	.02788	.534	.00720
		Chignik Lake	.471	.02788	.466	.00720
7/ 7	55	Black Lake	.186	.01011	.258	.00494
		Chignik Lake	.814	.01011	.742	.00494
7/10	60	Black Lake	.059	.00648	.114	.00239
		Chignik Lake	.941	.00648	.886	.00239
7/14	80	Black Lake	.096	.00494	.065	.00176
		Chignik Lake	.904	.00494	.935	.00176
7/20	80	Black Lake	.041	.00442	.046	.00104
		Chignik Lake	.959	.00442	.954	.00104

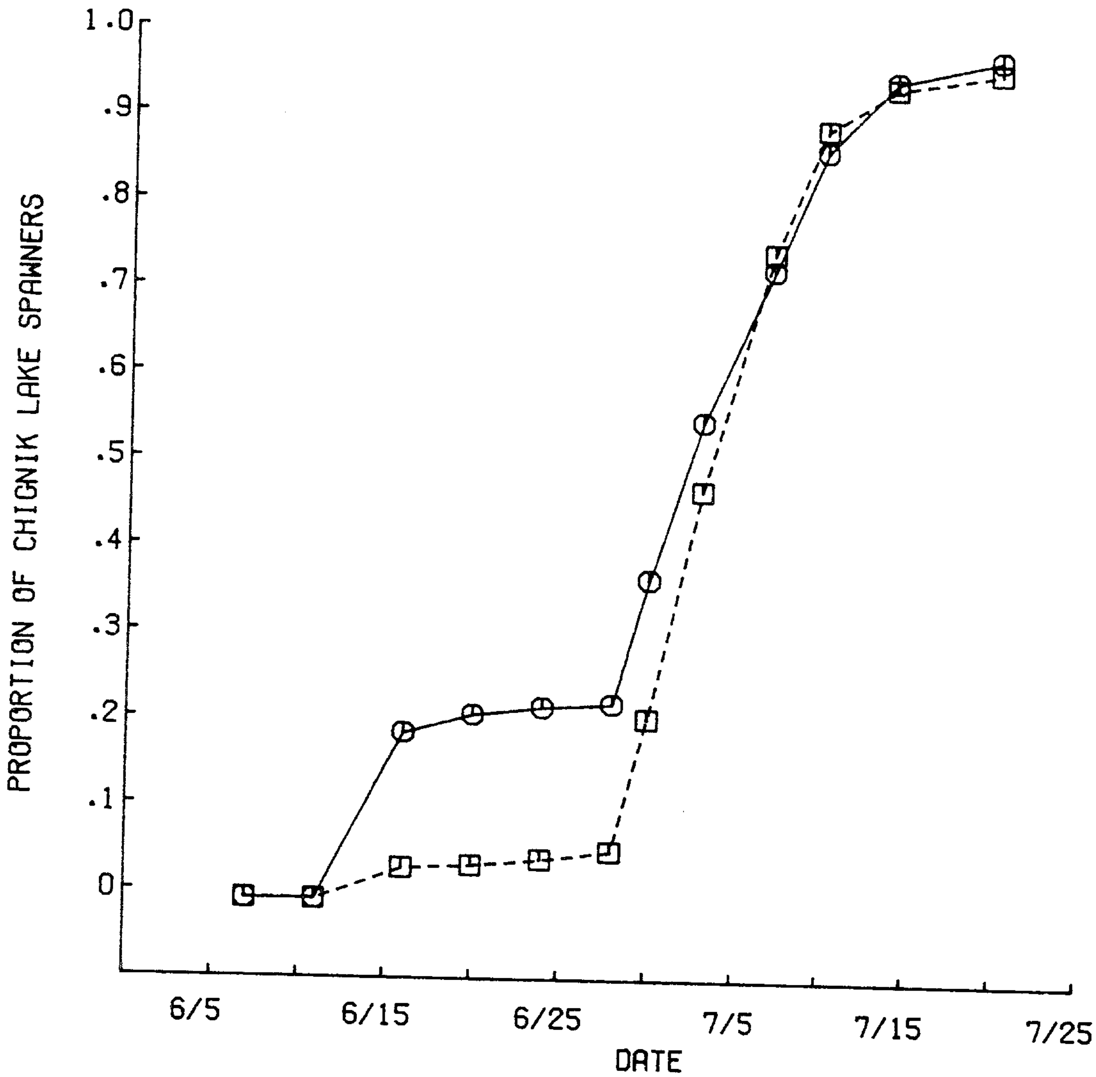

Figure 37. Comparison of the stock composition estimates for the 2.3 age class by the post-season (——) and in-season (---) analyses of the 1982 Chignik sockeye salmon run.

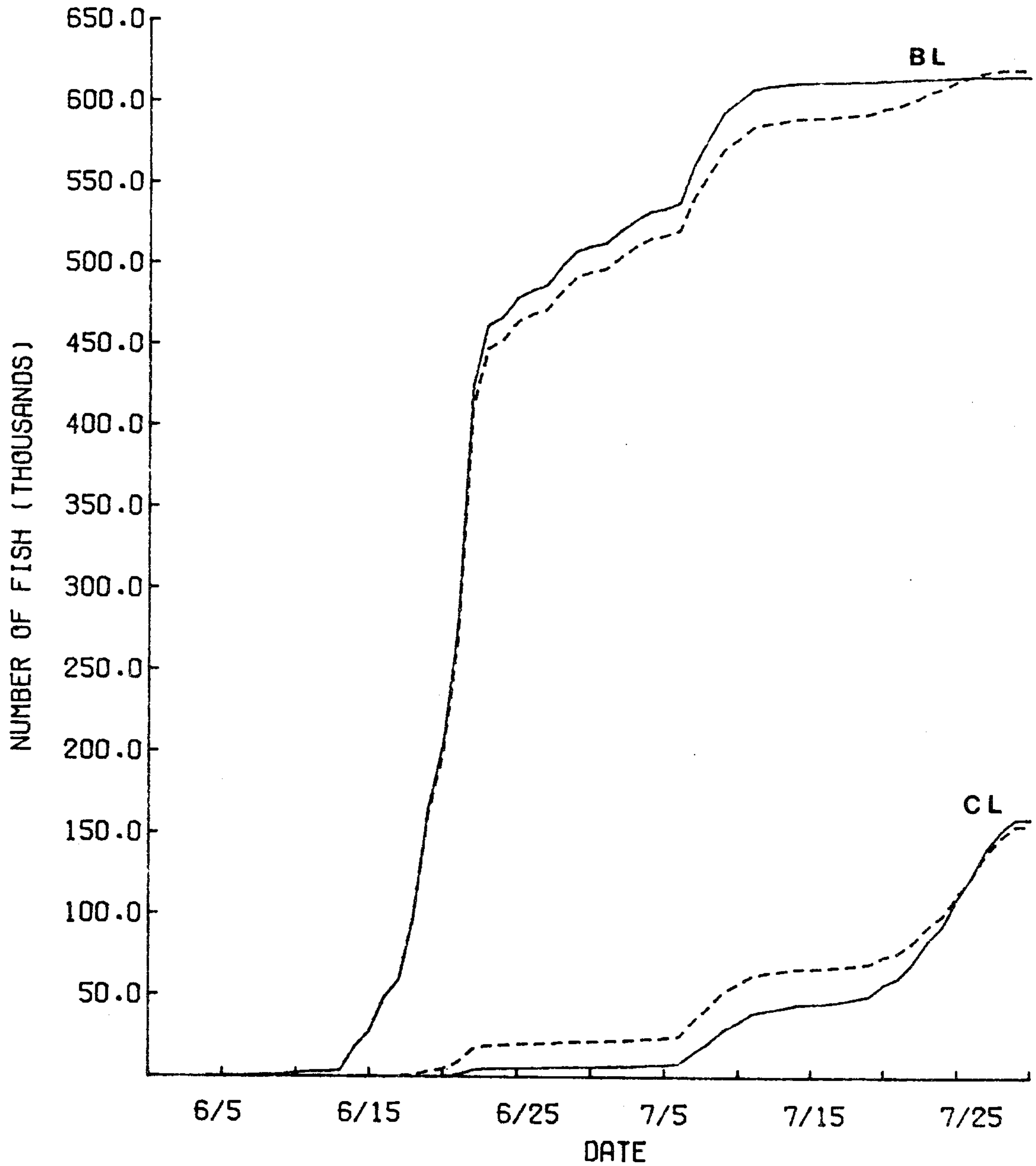

Figure 38. Comparison of the cumulative Black Lake and Chignik Lake escapement estimates by the post-season (——) and in-season (---) analyses of the 1982 Chignik sockeye salmon run.

Table 51. Classification accuracies of the linear discriminant functions for the 1978-1982 post-season analyses.

Year	Stock	Age	Sample Size	Classification Accuracy 2.2	1.3	2.3
1978	Black Lake	2.2	55	92.35		
	Chignik Lake	2.2	129			
	Black Lake	1.3	200		76.45	
	Chignik Lake	1.3	28			
	Black Lake	2.3	200			89.75
	Chignik Lake	2.3	200			
1979	Black Lake	2.2	99	78.35		
	Chignik Lake	2.2	200			
	Black Lake	1.3	200		72.55	
	Chignik Lake	1.3	35			
	Black Lake	2.3	200			93.50
	Chignik Lake	2.3	200			
1980	Black Lake	2.2	36	85.35		
	Chignik Lake	2.2	151			
	Black Lake	1.3	200		74.75	
	Chignik Lake	1.3	25			
	Black Lake	2.3	200			83.75
	Chignik Lake	2.3	200			
1981	Black Lake	1.3	200		74.90	
	Chignik Lake	1.3	126			
	Black Lake	2.3	140			79.55
	Chignik Lake	2.3	200			
1982	Black Lake	1.3	200		75.80	
	Chignik Lake	1.3	67			
	Black Lake	2.3	103			82.60
	Chignik Lake	2.3	200			
	Mean Classification Accuracy			85.35	74.89	85.83

Possible Standards for Evaluating the Accuracy of Each Method of Separating the Chignik Sockeye Salmon Stocks

Ideally, the two techniques for estimating the contribution of the Black Lake and Chignik Lake stocks to the sockeye salmon catch and escapement should be evaluated by comparing the estimates to actual observations for each stock. The escapement to the spawning grounds of each lake could provide a standard to evaluate the two methods if the total number of salmon on each stock's spawning grounds and an average age composition for the entire stock could be accurately determined by spawning ground surveys. Unfortunately this is not possible. Presently, escapements are counted by aerial surveys at the peak of spawning to estimate the Black River contribution to the early run. While they do provide an approximate index of abundance, the aerial surveys are not precise enough to evaluate a stock separation method (Nicholson et al. 1981).

The Alaska Department of Fish and Game conducts annual foot surveys of the principal Black Lake and Chignik Lake spawning grounds. During these surveys otoliths are collected to provide additional age composition information. If the age composition determined for a stock's spawning grounds by the otoliths was representative of the age composition of the entire stock, it could provide a standard for evaluation. Clutter and Whitesel (1956) discussed some of the general problems with estimating age composition by spawning ground surveys. Different recovery rates of spawned carcasses between sexes, and for length and age groups within sexes, can result in biased age composition estimates usually characterized by under-representation of the smaller 2-ocean and 1-ocean fish. If the age composition for the different spawning areas of a stock is not homogeneous, the extrapolation of the spawning ground age compositions to the entire stock is further complicated. This is not a problem for the Black Lake escapement which usually has similar age compositions for its different spawning areas. Sockeye from Chignik Lake spawning areas, however, often exhibit pronounced differences in age composition (Burgner and Marshall 1974). Also, one of the major Chignik Lake spawning areas, near the beach is never surveyed because it is difficult to obtain samples there.

An evaluation of the two stock separation techniques by a comparison of the age composition to the age compositions observed on the spawning grounds is not appropriate because of the possible biases of the spawning ground surveys. The discrepancy in lacustrine age interpretation between scales and otoliths is an additional problem. Burgner and Marshall (1974) found that for Black Lake, more otoliths were interpreted as having two lacustrine annuli than scales, while the reverse was true for Chignik Lake.

Another possible standard for evaluating the stock separation techniques might be provided by the scale samples collected at the outlet of Black Lake. Marshall and Burgner (1975) proposed that the age composition estimated from these samples be applied to the estimated Black Lake escapement. These samples might provide an age composition for the Black Lake escapement to compare with the age composition estimated by the stock separation techniques. It is questionable whether or not these samples are representative of the Black Lake escapement. It has not been determined if the sockeye salmon in this area are sufficiently mixed to present a random sample or if they assort themselves by time of arrival at the outlet. Aerial observations of Black Lake outlet and the river below it revealed that large schools of salmon are distributed throughout this area and they do not appear to mix (L. Nicholson, personal communication). If the schools are segregated by time of arrival at the outlet and if there are differences in the arrival time of the different age classes, as is indicated by the scale pattern analyses, then the Black Lake outlet samples are probably not representative of the entire Black Lake escapement. Therefore, there were no standards available which were precise enough to evaluate the stock separation techniques. Hence the techniques were evaluated by comparing the relative merits of each method rather than by determining which was more accurate.

Comparison of the Results of Separating the Chignik Sockeye Salmon Runs by Stock with Scale Pattern Analysis and the Average TOE Curve

The scale pattern analysis (SPA) method separates the total return by stock, but the average TOE curve separates it by early and late run. The early run consists primarily of the Black Lake stock plus the early Black River run, and the late run is primarily the Chignik Lake stock without the early Black River run. Although this is not a strict division by stock, as defined for this report, it will be considered as such because: (1) ADF&G no longer removes the Black River component of the early run for its annual run summary statistics; and (2) the early and late run division is used by ADF&G to estimate return-per-spawner relationships and for forecasting. A comparison of the total return by age class for the Black Lake and Chignik Lake stocks estimated by the SPA and TOE methods is given for each stock in Tables 52 and 53 for the Chignik sockeye salmon runs in 1978-1981 (TOE estimates were not available for 1982).

Substantial differences were apparent in the estimated age composition and in the estimated total return for each stock by the SPA and TOE methods. Table 54 summarizes the differences between the age composition percentages estimated by the SPA and TOE methods for the major age classes. Except in 1978, when the agreement between the estimates was good, there were large differences (greater than 18%) in the age composition estimates for at least one major age class in the three other years.

The difference between the SPA and the TOE estimates for the total return of the Black Lake stock are given in Table 54, also. For the years 1978-1981, the difference between the two estimates, expressed as a percentage of the total run for a year, varied from -4.4% to 10.1%. These differences may not appear to be extreme since three of them are less than 5%. When the Black River component of the early run is considered the differences between the SPA and TOE estimates become much greater. The percentage contribution of the Black River component to the early run was estimated by aerial surveys. The TOE estimates of the total early run were corrected to account for the Black River component to provide an estimate of the total Black Lake stock. The total difference between the estimates then increased in all years except 1981. The difference between the SPA and TOE estimates of the total return of the Black Lake stock then exceeded 5% in three of the four years.

Large differences between the total return and/or the age composition of each stock as estimated by the SPA and TOE methods were apparent in each of the years 1978-1981. The problem with separating the stocks by the average TOE curve have been presented previously (see Introduction). The following sections present the advantages of both methods and discuss some possible sources or error for the SPA method.

Table 52. Total return by age class for the Black Lake stock, 1978-1981, estimated by the scale pattern analysis method (SPA) and the average TOE curve (TOE)[1 2].

	Year	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
SPA	1978	0	333	50,713	121,029	4,588	752,716	587,019	6,752	3,190	264	0	1,526,604
	%	0.00	0.02	3.32	7.93	0.30	49.31	38.45	0.44	0.21	0.02	0.00	100.00
TOE	1978	200	200	10,738	108,513	2,350	656,997	486,119	3,529	4,923	0	0	1,273,569
	%	0.02	0.02	0.84	8.52	0.18	51.59	38.17	0.28	0.38	0.00	0.00	100.00
SPA	1979	506	1,777	19,444	114,405	1,387	120,290	315,871	2,496	0	809	0	576,985
	%	0.09	0.31	3.37	19.83	0.24	20.85	54.74	0.43	0.00	0.14	0.00	100.00
TOE	1979	163	1,019	29,905	98,599	0	207,266	293,139	0	0	0	0	630,091
	%	0.03	0.16	4.75	15.65	0.00	32.89	46.52	0.00	0.00	0.00	0.00	100.00
SPA	1980	99	85	42,633	53,609	533	69,370	295,048	1,752	112	494	2,357	466,092
	%	0.02	0.02	9.15	11.50	0.11	14.88	63.30	0.38	0.02	0.11	0.51	100.00
TOE	1980	0	0	29,787	27,499	0	178,363	165,987	50	50	231	0	401,967
	%	0.00	0.00	7.41	6.84	0.00	44.37	41.30	0.01	0.01	0.06	0.00	100.00
SPA	1981	223	370	56,257	23,572	1,004	636,001	424,922	2,591	960	429	11,190	1,157,519
	%	0.02	0.03	4.86	2.04	0.09	54.94	36.71	0.22	0.08	0.04	0.97	100.00
TOE	1981	0	0	87,839	23,750	0	945,363	231,133	0	0	0	0	1,288,085
	%	0.00	0.00	6.82	1.84	0.00	73.39	17.95	0.00	0.00	0.00	0.00	100.00

[1] The TOE method includes the early arriving portion of the Black River run.

[2] Source: Nicholson et al. 1981.

Table 53. Total return by age class for the Chignik Lake stock, 1978-1981, estimated by the scale pattern analysis method (SPA) and the average TOE curve (TOE)[1 2].

		Age											
	Year	1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other	Total
SPA	1978	0	2,653	18,509	166,073	29,542	54,455	689,613	13,329	94	2,728	0	976,996
	%	0.00	0.27	1.90	17.00	3.02	5.57	70.59	1.36	0.01	0.28	0.00	100.00
TOE	1978	497	2,552	5,973	158,782	76,657	79,577	838,540	39,097	2,505	0	690	1,204,870
	%	0.04	0.21	0.50	13.18	6.36	6.60	69.60	3.24	0.21	0.00	0.06	100.00
SPA	1979	1,070	6,911	23,811	191,055	3,736	102,319	892,112	3,587	0	259	0	1,224,860
	%	0.09	0.57	1.94	15.60	0.31	8.35	72.83	0.29	0.00	0.02	0.00	100.00
TOE	1979	1,878	1,236	69,413	150,051	0	336,091	588,080	0	0	0	0	1,146,749
	%	0.16	0.11	6.05	13.09	0.00	29.31	51.28	0.00	0.00	0.00	0.00	100.00
SPA	1980	252	807	59,291	185,502	2,037	123,709	678,022	4,759	51	1,249	2,705	1,058,384
	%	0.02	0.08	5.60	17.53	0.19	11.69	64.06	0.45	T[3]	0.12	0.26	100.00
TOE	1980	0	0	38,301	211,814	0	135,481	736,942	0	0	352	0	1,122,890
	%	0.00	0.00	3.41	18.86	0.00	12.07	65.63	0.00	0.00	0.03	0.00	100.00
SPA	1981	416	3,918	52,041	92,999	3,522	764,753	847,360	9,130	901	2,283	7,500	1,784,823
	%	0.02	0.22	2.91	5.21	0.20	42.85	47.48	0.51	0.05	0.13	0.42	100.00
TOE	1981	0	0	38,090	90,027	0	549,243	985,926	0	0	0		1,663,286
	%	0.00	0.00	2.29	5.41	0.00	33.02	59.28	0.00	0.00	0.00	0.00	100.00

1 The TOE method does not include the early arriving portion of the Black River run.

2 Source: Nicholson, et al. 1981.

3 Trace < 0.005%.

Table 54. Differences between the scale pattern analysis method and the average TOE[1] method for the estimates of the percentage of the major age classes in the total Black Lake return.

Year	Stock	% Difference by age[2] 1.2	2.2	1.3	2.3	Difference for total Black Lake return	% of total return	Black River % of early run	Total % difference
1978	BL	2.5	-0.6	-2.3	0.3	253,035	10.1	6.3	13.3
	CL	1.4	3.8	-1.0	1.0				
1979	BL	-1.4	4.2	-12.0	8.2	-53,106	-2.9	15.1	5.3
	CL	-4.1	2.5	-21.0	21.6				
1980	BL	1.7	4.7	-29.5	22.0	64,125	4.2	17.7	8.9
	CL	2.2	-1.3	-0.4	-1.6				
1981	BL	-2.0	0.2	-18.5	18.8	-130,566	-4.4	7.0	-1.4
	CL	0.6	-0.2	9.8	-11.8				

1 Source: Nicholson et al. 1981.

2 SPA method - TOE method.

Advantages of the Scale Pattern Analysis Method of Separating the Chignik Sockeye Salmon Stocks

The advantages of the scale pattern analysis method of separating the Chignik sockeye salmon stocks are:

1. Estimates are year-specific and are based on information collected in the year of analysis. The average TOE curve was developed from observations made from 1962 to 1969 and it has not been evaluated since that time. The average TOE curve is not year-specific but defines an average pattern of entry for the Chignik sockeye salmon stocks. It is not sensitive to annual changes in the entry pattern and does not recognize entry patterns different from the ideal.

2. The SPA method estimates the stock composition of the run from samples collected during June and July and uses all these samples to define the entry patterns of the major age classes in the run. The decision on the placement of the average TOE curve is not made from information collected during the run but depends on the management biologist's perception of the run. There is no information supporting his decision.

3. For any day during the period of transition, the SPA method usually estimates the stock compositon of each of the major age classes present. It recognizes differences in age composition between the stocks and differences in the time-of-entry of the age classes within a stock because it is age-specific. The average TOE method applies the same age composition estimates to both stocks which obscures their difference in age composition. Also, it applies one pattern of entry to all age classes.

4. The SPA method separates the run by nursery lake stock, not by early and late run. The separation by stock is a much better procedure for management because the optimum escapement estimates are for each nursery lake, not for the early and late runs. Run statistics summarized by stock have more biological meaning for spawner-recruit relationships than a division by early and late run.

5. A division of the Chignik sockeye salmon run by stock and an accurate estimate of the age composition of each stock is important for forecasting. The return of 2-ocean fish has proved to be an important variable in the forecast of the next year's run to each lake (S. Parker, personal communication). Improved estimates of the 2-ocean component in the return of each stock could help to improve the forecast for each stock.

Possible Sources of Error for the Scale Pattern Analysis Method

Violations of the assumptions necessary for linear discriminant function analysis could affect the models which estimated the stock composition of the Chignik Lagoon samples and cause errors in the estimates. Each population in the LDF analysis should be discrete and identifiable. For the Black Lake standards, all scale samples were collected at Black Lake outlet and there were probably no fish of Chignik Lake origin present because it is removed from any Chignik Lake spawning area. Chignik Lake standards collected in Chignik Lagoon could have included some fish from the Black Lake stock.

The assumption of multivariate normality of the scale characters in each LDF could have been violated, also. This assumption was not rigorously examined because no test of the hypothesis of multivariate normality was available. All scale characters used in the LDF analyses were approximately univariate normal but this does not guarantee that their multivariate distributions were normal.

The assumption of equal covariance matrices for the groups in the LDF analysis was tested for all analyses. In 12 of the 13 post-season LDF analyses, the hypothesis of equal covariance matrices was rejected ($\alpha = 0.05$). Quadratic discriminant function (QDF) analysis would have been more appropriate because it does not require the equality of covariance matrices. This does not invalidate the results of the linear assignment rule, however. When this assumption is violated, Fisher's LDF may still be satisfactory for classification (Gilbert 1969; Kzranowski 1977). The advantage of QDF analysis over LDF analysis occurs when there are significant differences between the variances of the variables used in the analysis. The additional information provided by the difference in variances can increase the accuracy of the QDF. There were no large differences between the variances of the scale characters for the two Chignik stocks and they were usually multiples of 2 or less of one another. It is doubtful whether the accuracy of the QDF would be significantly better than the LDF since there were no large differences in the variances.

The scale samples collected in Chignik Lagoon to estimate the stock composition of the run during the period of transition could be another possible source of error. The possibility of collecting samples that were not representative of the run was previously mentioned. The stock and age composition of scale samples collected in the Lagoon are probably influenced by the area of collection and the time of collection. The commercial fishery is dispersed throughout Chignik Lagoon, from its outlet to Chignik Bay to the mouth of Chignik River, and operates from early in the morning to late at night. Changes in the composition of the run might be expected for samples collected in different areas and at different times. The concept of a sample being representative of all fish in the catch or escapement on a particular day is oversimplified. Until the complexities of the spatial and temporal changes in the run within Chignik Lagoon are investigated further, there is no alternative to the present sampling method.

Other possible sources of error are: (1) the assumption of a one-day migration time from Chignik Lagoon to the weir; (2) errors in aging the scales; and (3) errors in the daily abundance estimates.

Advantages of the Average Time-of-Entry Curve for Separating the Chignik Sockeye Salmon Stocks

The major advantage of using the average time-of-entry curve to separate the Chignik sockeye salmon run by stock is its ease of use. Only the basic run statistics, daily escapement and catch, and age composition estimates are required for the average TOE method. Large numbers of scales must be measured and analyzed for the scale pattern analysis method. For the 1978-1982 post-season analyses, an average of 2,600 scales were measured for each year to provide the age-specific stock composition estimates. Even with the microcomputer controlled digitizing system, about one man-month was required to measure the scales for each year's analysis. The average TOE method requires no additional labor beyond aging the scales to estimate each stock's contribution to the run.

Evaluation of the In-season Stock Separation Analysis

The results of the in-season separation of the Chignik sockeye salmon stocks by scale patterns and linear discriminant function analysis were compared to the results of the post-season analyses. Only estimates of the total daily escapement by stock are necessary for the in-season analysis. In 1979, 1981, and 1982 the cumulative escapements by stock estimated by the in-season and post-season analyses were very similar. In 1980, there was a difference between the in-season and post-season analyses of more than 150,000 fish for the estimated total Black Lake escapement. The lacustrine scale patterns of the 1979 age 2.2 Chignik Lake standard did not resemble those of the 1980 age 2.3 Chignik Lake standard as closely as the other 2.2-2.3 Chignik Lake standard comparisons. The percentage of the actual 2.3 standard classified as Chignik Lake origin by the 1980 in-season model (69.0%) was significantly less than for the other years.

The in-season method of separating the Chignik sockeye salmon stocks by analysis of their scale patterns needs to be examined further before it can be properly evaluated. It must be determined if the poor performance in 1980 was an isolated occurrence or if similar results can be expected frequently.

The advantage of the in-season method of separating the Chignik stocks in comparison to the average TOE method are similar to the advantages of the post-season method. The in-season method: (1) estimates the stock composition of the run from data collected throughout the run; (2) is year-specific rather than being an average of data from a number of years; and (3) separates the escapement by stock instead of by early run and late run.

A possible source of error for the in-season analyses, in addition to those discussed for the post-season analyses, is estimating the stock composition of only one age class in the run. Differences in the entry patterns of the major age classes in the run were apparent in the post-season analyses. The effects of this on the in-season estimates may not be very severe because the in-season method estimates the number of each stock in the escapement and is not concerned with the age composition.

SUMMARY

1. Many studies have identified Pacific salmon stocks by their scale patterns and discriminant function analysis. In almost all previous studies the stocks have come from different river or lake systems. There have been very few studies separating the stocks within a single watershed.

2. The sockeye salmon run to the Chignik lakes is the largest in Alaska outside of Bristol Bay (the ten-year average return is 2.03 million fish). Effective management of the Chignik sockeye salmon run requires that its two major stocks can be identified in the catch and escapement.

3. The Chignik sockeye salmon stocks were defined by the nursery lake where they spend their early freshwater life, Black Lake or Chignik Lake.

4. Dahlberg (1968) devised a procedure for separating the Chignik sockeye salmon run by stock from tagging studies conducted from 1962-1966. For each year, a curve defining the average time-of-entry of each stock was calculated.

5. Optimum escapement estimated for each stock were approximately 400,000 for Black Lake and 200,000 for Chignik Lake. The commercial fishery has been regulated to ensure that these goals were met since 1967.

6. Since 1970, a TOE curve which is the average of tagging data from 1962-1969 has been used to estimate the contribution of each stock to the catch and escapement. Problems with the average TOE curve have been discussed by other researchers.

7. Objectives of this study were to determine if the major age classes in the Chignik sockeye salmon run could be separated by stock with discriminant function analysis of their scale patterns and to develop a procedure for separating the run by stock and age class in a post-season analysis. The possibility of estimating the stock composition of the run in-season with scale pattern analysis was examined, also.

8. Measurements and circuli counts in each lacustrine annular zone of a scale and a linear discriminant function were used to identify the Black Lake and Chignik Lake stocks.

9. Scale samples collected at the outlet of Black Lake were used for the Black Lake standards. Scale samples collected in Chignik Lagoon after 24 July were used to establish Chignik Lake standards. Samples collected in Chignik Lagoon were used to estimate the age and stock composition of the run.

10. A post-season analysis of each of the Chignik runs from 1978-1982 estimated the total return by age class for each stock with linear discriminant function analysis of lacustrine scale patterns. The average classification accuracy for the major age classes in the run during these years was: 85.4% for the 2.2 age class; 74.9% for the 1.3 age class; and 85.8% for the 2.3 age class.

11. Differences in the pattern of entry for a stock were observed for each age class analyzed and between the years analyzed.

12. A linear discriminant function for an in-season analysis of the age class was calculated from the Black Lake samples in the year of analysis and the 2.2 Chignik Lake standard from the previous year.

13. The in-season estimates of the cumulative escapement by stock were very close to the post-season estimates for the 1979, 1981, and 1982 in-season analyses. The estimates in 1980 differed by more than 150,000 fish for the estimated Black Lake escapement.

14. The advantage of the scale pattern analysis method of separating the Chignik sockeye salmon stocks are: it is year-specific and age-specific; is deter-

mined from data collected throughout the run; and it separates the run by nursery lake stock.

15. The in-season analysis method of estimating the cumulative escapement by stock requires further examination before it can totally replace the average TOE curve for in-season analyses.

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This Informational Leaflet is substantially identical to the author's University of Washington Master's thesis (1983) of the same title.

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APPENDICES

Appendix Table 1a. Format used to record the descriptive information for each scale measured.

Identifier	Column(s)	Code or explanation
Scale number	1-2	Position of scale on scale card
Sex	3	1 = male, 2 = female, 3 = unknown
Length	4-6	Mideye-to-fork-of-tail length, in mm
Sample number	7-9	Scale card number
Date of sampling	10-11 12-13 14-15	Year Month Day
Sampling location	16	1 = Chignik Lagoon 2 = Chignik River 3 = Chignik Lake 4 = Black Lake outlet 5 = Black River
Stock	17	1 = Black Lake 2 = Chignik Lake 3 = Unknown
Age	18 19	Number of freshwater annuli Number of marine annuli

Appendix Table 1b. Format used to record the count and measurement information for each scale processed. All distances are recorded to the nearest 0.01 inch.

Measurement or count	Column(s)
Number of circuli in the first lacustrine annular zone	20-21
Width of the first lacustrine annular zone	22-25
14 fields of 3 digits recording the distance from the scale focus to each circulus in the first lacustrine annular zone	26-67
Number of circuli in the second lacustrine annular zone, if present	68-69
Width of the second lacustrine annular zone	70-73
14 fields of 3 digits recording the distance from the scale focus to each circulus in the second lacustrine annular zone	74-115
Number of circuli of lacustrine plus growth, if present	116-117
Width of the zone of lacustrine plus growth	118-121

Appendix Table 2. Scale characters examined for use in the linear discriminant function analyses.

First lacustrine annular zone

Character	Definition
1	number of circuli in the annular zone
2	width of the annular zone
3-10	distance from the scale focus to each of the first eight circuli in the zone
11-18	the ratio of characters 3-10 to the width of the zone
19-22	distance between the first, second, third, and fifth circuli before the first annulus and the end of the zone
23-26	the ratio of character 19-22 to the width of the zone
27	average interval between circuli in the zone
28	number of circuli in the first 3/4 of the zone
29-33	distance between every consecutive pair of circuli between the first and the sixth circuli in the zone
34-38	the ratio of characters 29-33 to the width of the zone
39-42	distance between every second circulus between the first and the sixth circuli in the zone
43-46	the ratio of characters 39-42 to the width of the zone
47-49	distance between every third circulus between the first and the sixth circuli in the zone
50-52	the ratio of characters 47-49 to the width of the zone
53	distance between the first and fifth circuli in the zone
54	distance between the first and sixth circuli in the zone
55-56	the ratio of characters 53-54 to the width of the zone
57	distance from the first circulus to the end of the zone

-Continued-

Appendix Table 2. Scale characters examined for use in the linear discriminant function analyses (continued).

First lacustrine annular zone

Character	Definition
58	distance from the second circulus to the end of the zone
59	the ratio of character 57 to the width of the zone
60	width of the widest pair of circuli in the zone
61	the ratio of character 60 to the width of the zone
62	the first circulus of the widest pair in the zone
Second lacustrine annular zone (if present)	
1	number of circuli in the annular zone
2	width of the annular zone
3-8	distance from the end of the first lacustrine annulus to each of the first six circuli in the zone
9-14	the ratio of characters 3-8 to the width of the zone
15-17	distance between the first, second, and fourth circuli before the second annulus and the end of the zone
18-20	the ratio of characters 15-17 to the width of the zone
21	average interval between circuli in the zone
22	number of circuli in the first half of the zone
23	number of circuli in the first 3/4 of the zone
24-28	distance between every consecutive pair of circuli between the first and the sixth circuli in the zone
29-33	the ratio of characters 24-28 to the width of the zone
34-37	distance between every second circulus between the first and the sixth circuli in the zone
38-41	the ratio of characters 34-37 to the width of the zone

-Continued-

Appendix Table 2. Scale characters examined for use in the linear discriminant function analyses (continued).

Second lacustrine annular zone (if present)

Character	Definition
42-44	distance between every third circulus between the first and the sixth circuli in the zone
45-47	the ratio of characters 42-44 to the width of the zone
48	distance between the first and fifth circuli in the zone
49	distance between the second and sixth circuli in the zone
50-51	the ratio of characters 48-49 to the width of the zone
52	distance between the first circulus and the end of the zone
53	distance between the second circulus and the end of the zone
54-55	the ratio of characters 52-53 to the width of the zone
56	width of the widest pair of circuli in the zone
57	the ratio of character 56 to the width of the zone
58	the first circulus of the widest pair in the zone
59	total number of annular circuli (both annular zones)
60	total width of the annular zone (both annular zones)
61	the ratio of character 60 to character 59
62	the ratio of the width of the first annular zone to character 60
Lacustrine plus growth zone (if present)	
1	number of circuli in the plus growth zone
2	width of the plus growth zone
3	total number of lacustrine circuli (including plus growth)

-Continued-

Appendix Table 2. Scale characters examined for use in the linear discriminant function analyses (continued).

Lacustrine plus growth zone (if present)

Character	Definition
4	total width of the lacustrine zone (including plus growth
5	the ratio of the width of the total annular zone to the width of the total lacustrine zone
6	the ratio of the width of the first annular zone to character 4

Appendix Table 3a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1978.

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
5/22	0	0	0	0	0	0	0	0	0	0
5/23	0	0	0	0	0	0	0	0	0	0
5/24	0	0	0	0	0	0	0	0	0	0
5/25	0	0	0	0	0	0	0	0	0	0
5/26	1,000[1]	0	0	0	0	0	0	0	0	1,000
5/27	1,000[1]	0	0	0	0	0	0	0	0	1,000
5/28	1,008	0	0	0	0	0	0	0	0	1,008
5/29	1,152	0	0	0	0	0	0	0	0	1,152
5/30	1,200	0	0	0	0	0	0	0	0	1,200
5/31	2,369	0	0	0	0	0	0	0	0	2,369
6/ 1	7,200	0	0	0	0	0	0	0	0	7,200
6/ 2	1,680	0	0	0	0	0	0	0	0	1,680
6/ 3	7,435	0	0	0	0	0	0	0	0	7,435
6/ 4	11,929	0	0	0	0	0	0	0	0	11,929
6/ 5	23,094	0	0	0	0	0	0	0	0	23,094
6/ 6	11,577	0	0	0	0	0	0	0	0	11,577
6/ 7	10,435	0	0	0	0	0	0	0	0	10,435
6/ 8	6,720	0	0	0	0	0	0	0	0	6,720
6/ 9	24,700	118,402	0	0	0	0	0	0	0	143,102
6/10	18,426	0	0	0	0	0	0	0	0	18,426
6/11	24,036	0	0	1,554	0	0	0	0	0	25,590
6/12	17,382	102,170	0	0	0	0	0	0	0	119,552
6/13	25,156	0	0	0	0	0	0	0	0	25,156
6/14	24,524	52,645	0	4,145	0	21,976	0	0	0	103,290
6/15	22,056	0	0	0	0	0	0	0	0	22,056
6/16	12,265	84,229	0	146	0	0	0	0	0	96,640
6/17	19,526	63,530	0	0	0	0	0	0	1,367	84,423
6/18	47,496	0	0	2,332	0	0	0	0	2,242	52,070
6/19	15,146	0	0	5,267	0	0	0	0	2,036	22,449
6/20	6,045	69,822	0	0	0	19,602	0	0	0	95,469
6/21	12,659	52,396	3,000	0	0	9,759	0	0	0	77,814
6/22	22,514	0	1,613	2,654	0	27,379	0	0	0	54,160

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Appendix Table 3a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1978 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
6/23	4,048	45,979	0	1,825	0	0	0	0	0	51,852
6/24	7,615	23,544	525	0	0	0	0	0	1,064	32,748
6/25	14,596	0	5,891	0	0	18,580	0	0	423	39,490
6/26	9,842	35,280	0	1,392	0	30,858	0	0	887	78,259
6/27	4,034	19,974	4,241	0	0	11,353	0	0	0	39,602
6/28	2,935	31,045	2,529	260	0	0	0	0	0	36,769
6/29	1,947	14,840	2,174	1,224	0	2,488	0	0	0	22,673
6/30	2,673	28,204	1,176	5,306	0	0	0	0	0	37,359
7/ 1	4,195	0	1,375	3,204	0	0	0	0	0	8,774
7/ 2	2,724	37,623	0	2,629	0	0	0	0	1,269	44,245
7/ 3	1,224	24,650	0	0	0	0	0	0	1,877	27,751
7/ 4	2,172	0	5,891	36	0	0	0	0	3,378	11,477
7/ 5	3,258	0	0	1,172	0	0	0	0	0	4,430
7/ 6	1,578	78,604	0	0	0	0	0	0	0	80,182
7/ 7	1,914	0	1,564	0	0	0	0	0	0	3,478
7/ 8	1,554	71,677	0	2,238	0	0	0	0	178	75,647
7/ 9	4,542	0	501	0	0	0	0	0	3,099	8,142
7/10	10,260	0	0	1,639	0	0	0	0	1,473	13,372
7/11	7,266	0	0	0	0	0	0	0	0	7,266
7/12	4,092	124,898	0	0	0	102	0	0	62	129,154
7/13	2,862	0	194	0	0	0	0	0	0	3,056
7/14	6,978	0	0	1,545	0	2,088	0	0	0	10,611
7/15	2,934	0	0	0	0	107	0	0	756	3,797
7/16	15,846	0	0	0	0	122	0	0	0	15,968
7/17	34,303	0	0	0	0	0	0	0	0	34,303
7/18	12,654	0	102	0	0	0	0	0	3,727	16,483
7/19	5,972	217,467	1,714	0	0	0	382	0	0	225,535
7/20	8,412	0	0	107	0	0	12	0	0	8,531
7/21	16,569	0	385	342	0	12,414	0	0	0	29,710
7/22	8,520	0	2,396	1,787	0	2,643	0	0	0	15,346
7/23	2,376	53,404	221	572	0	0	0	0	197	56,770
7/24	4,314	0	0	1,811	0	0	1	0	114	6,240

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Appendix Table 3a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1978 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
7/25	4,362	21,941	1,238	326	0	17,955	4	0	0	45,826
7/26	6,240	0	0	422	0	23,483	0	0	0	30,145
7/27	6,894	0	411	956	0	5,809	17	0	0	14,087
7/28	3,954	12,054	226	919	0	7,981	101	28	0	25,263
7/29	5,856	0	0	2,224	0	2,411	494	3	0	10,988
7/30	5,450	0	0	2,249	0	538	555	1	90	8,883
7/31	2,520	7,643	0	0	0	0	62	3	77	10,305
8/ 1	1,932	5,770	0	0	0	0	1	0	22	7,725
8/ 2	1,278	4,603	67	1,392	0	0	302	0	559	8,201
8/ 3	1,800	4,160	0	1,132	0	0	550	2	0	7,644
8/ 4	972	5,046	0	883	0	0	390	0	0	7,291
8/ 5	2,832	0	2	1,232	0	1	475	39	608	5,189
8/ 6	5,124	0	0	955	55	1	217	27	536	6,915
8/ 7	4,386	7,476	0	0	1	4	0	13	0	11,880
8/ 8	1,662	4,704	0	0	0	0	0	0	0	6,366
8/ 9	1,596	3,860	4	987	0	0	231	0	39	6,717
8/10	1,800[2]	5,174	148	1,829	0	0	252	4	18	9,225
8/11	1,000	4,997	51	541	0	0	290	2	40	6,921
8/12	2,800	0	0	0	0	0	93	1	178	3,072
8/13	5,100	0	0	0	0	0	46	0	0	5,146
8/14	4,400	5,814	0	0	0	0	0	0	0	10,214
8/15	1,700	5,889	58	0	0	0	0	0	7	7,654
8/16	1,600	5,306	0	0	0	0	0	0	0	6,906
8/17	1,000	4,515	0	0	0	10	0	0	0	5,525
8/18	1,000	4,902	0	0	0	0	0	1	0	5,903
8/19	1,500	0	0	0	0	0	0	2	74	1,576
8/20	2,000	0	0	0	0	0	0	4	0	2,004
8/21	1,500	3,168	0	0	0	0	0	3	0	4,671
8/22	500	1,350	0	0	0	0	0	0	78	1,928
8/23	500	1,511	0	0	0	0	7	0	0	2,018
8/24	500	986	0	0	0	0	0	8	0	1,494

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Appendix Table 3a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1978 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
8/25	500	1,572	0	0	0	0	0	0	26	2,098
8/26	500	0	0	0	0	0	0	0	0	500
8/27	500	0	0	0	0	0	0	0	0	500
8/28	500	664	0	0	0	0	0	0	0	1,164
8/29	250	587	0	0	0	0	0	0	0	837
8/30	250	213	0	0	0	0	0	0	0	463
8/31	250	0	0	0	0	0	0	0	0	250
9/ 1	250	62	0	0	0	0	0	0	0	312
9/ 2	250	0	0	0	0	0	0	0	0	250
9/ 3	250	0	0	0	0	0	0	0	0	250
9/ 4	250	209	0	0	0	0	0	0	0	459
9/ 5	100	61	0	0	0	0	0	0	0	161
9/ 6	100	47	0	0	0	0	0	0	13	160
9/ 7	100	0	0	0	0	0	0	0	0	100
9/ 8	100	6	0	0	0	0	0	0	0	106
9/ 9	100	0	0	0	0	0	0	0	2	102
9/10	100	0	0	0	0	0	0	0	28	128
9/11	100	0	0	0	0	0	0	0	131	231
9/12	100	0	0	0	0	0	0	0	135	235
9/13	100	0	0	0	0	0	0	0	126	226
9/14	100	0	0	0	0	0	0	0	0	100
9/15	100	0	0	0	0	0	0	0	0	100
9/16	0	0	0	0	0	0	0	0	0	0
9/17	0	0	0	0	0	0	0	0	114	114
9/18	0	0	0	0	0	0	0	0	0	0
9/19	0	0	0	0	0	0	0	0	22	22
9/20	0	0	0	0	0	0	0	0	34	34
9/21	0	0	0	0	0	0	0	0	0	0
9/22	0	0	0	0	0	0	0	0	0	0
9/23	0	0	0	0	0	0	0	0	0	0
9/24	0	0	0	0	0	0	0	0	0	0
9/25	0	0	0	0	0	0	0	0	0	0

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Appendix Table 3a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1978 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
9/26	0	0	0	0	0	0	0	0	0	0
9/27	0	0	0	0	0	0	0	0	0	0
9/28	0	0	0	0	0	0	0	0	0	0
9/29	0	0	0	0	0	0	0	0	0	0
9/30	0	0	0	0	0	0	0	0	0	0
Total	682,547	1,474,673	37,697	59,234	56	217,664	4,482	141	27,106	2,503,600

[1] Escapement estimated.

[2] All escapements after 8/9 estimated.

Appendix Table 3b. Age composition of sockeye salmon scale samples collected in Chignik Lagoon during 1978, by percent of sample.

Sample Date	Sample Size	Age										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/ 9	209	0.0	0.0	1.9	1.4	0.0	67.0	29.2	0.0	.5	0.0	0.0
6/12	124	0.0	0.0	4.8	5.6	0.0	70.2	18.6	0.0	.8	0.0	0.0
6/17	123	0.0	0.0	1.6	7.3	0.0	63.4	27.7	0.0	0.0	0.0	0.0
6/20	124	0.0	0.0	4.0	4.0	0.0	55.7	36.3	0.0	0.0	0.0	0.0
6/23	129	0.0	0.0	6.2	20.1	0.0	41.1	32.6	0.0	0.0	0.0	0.0
6/27	122	0.0	0.0	5.7	11.5	0.0	25.4	56.6	.8	0.0	0.0	0.0
6/30	86	0.0	0.0	3.5	5.8	0.0	24.4	65.1	1.2	0.0	0.0	0.0
7/ 3	104	0.0	1.0	6.7	11.5	0.0	13.5	65.4	1.9	0.0	0.0	0.0
7/ 6	135	0.0	0.0	.7	10.4	.7	5.9	80.8	1.5	0.0	0.0	0.0
7/ 8	117	0.0	0.0	0.0	3.4	.8	10.3	82.1	2.6	0.0	.8	0.0
7/12	127	0.0	0.0	.8	9.4	2.4	1.6	82.7	3.1	0.0	0.0	0.0
7/19	129	0.0	0.0	1.5	13.2	1.5	1.6	80.6	1.6	0.0	0.0	0.0
7/23	125	0.0	0.0	1.6	25.6	8.0	4.8	60.0	0.0	0.0	0.0	0.0
7/25	122	0.0	.8	.8	37.7	8.2	4.9	47.6	0.0	0.0	0.0	0.0
7/28	104	0.0	1.0	1.0	32.6	6.7	1.0	56.7	1.0	0.0	0.0	0.0
8/ 1	121	0.0	.8	3.3	33.9	8.3	3.3	47.9	.8	0.0	1.7	0.0
8/ 7	135	0.0	0.0	2.2	25.2	1.5	4.5	63.7	.7	0.0	2.2	0.0
8/15	64	0.0	1.6	0.0	7.8	4.7	9.3	75.0	1.6	0.0	0.0	0.0
8/23	59	0.0	0.0	3.4	23.7	1.7	5.1	62.7	1.7	0.0	1.7	0.0

Appendix Table 3c. Age composition of sockeye salmon scale samples collected at Black Lake outlet during 1978, by percent of sample.

Sample Date	Sample Size	Age										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/12	172	0.0	0.0	2.3	2.3	0.0	75.0	20.4	0.0	0.0	0.0	0.0
6/15	154	0.0	0.0	.7	1.9	0.0	75.3	22.1	0.0	0.0	0.0	0.0
6/17	174	0.0	0.0	2.9	6.3	0.0	68.4	22.4	0.0	0.0	0.0	0.0
6/19	214	0.0	0.0	1.9	3.3	0.0	79.4	15.4	0.0	0.0	0.0	0.0
6/21	177	0.0	0.0	1.1	2.8	0.0	75.7	20.4	0.0	0.0	0.0	0.0
6/23	174	0.0	0.0	1.1	4.6	0.0	79.3	14.4	0.0	.6	0.0	0.0
6/25	145	0.0	0.0	4.1	8.3	0.0	69.7	17.9	0.0	0.0	0.0	0.0
6/27	27	0.0	0.0	7.4	0.0	0.0	77.8	14.8	0.0	0.0	0.0	0.0
7/ 1	227	0.0	0.0	2.6	4.4	0.0	62.6	30.4	0.0	0.0	0.0	0.0
7/ 5	131	0.0	0.0	2.3	2.3	0.0	71.0	24.4	0.0	0.0	0.0	0.0
Mean[1]		0.0	0.0	2.11	4.02	0.0	72.93	20.87	0.0	0.07	0.0	0.0

[1] Does not include the sample on 6/27.

Appendix Table 3d. Summary of the daily and cumulative return of sockeye salmon for the Black Lake stock in 1978.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 5/31	5,350	0	5,350	5,350	.004
5/31	2,358	0	2,358	7,708	.005
6/ 1	7,157	0	7,157	14,865	.010
6/ 2	1,669	0	1,669	16,534	.011
6/ 3	7,376	0	7,376	23,910	.016
6/ 4	11,822	0	11,822	35,732	.023
6/ 5	22,863	0	22,863	58,595	.038
6/ 6	11,449	0	11,449	70,044	.046
6/ 7	10,309	0	10,309	80,353	.053
6/ 8	6,632	0	6,632	86,985	.057
6/ 9	24,353	116,745	141,098	228,083	.149
6/10	18,141	0	18,141	246,224	.161
6/11	23,637	1,528	25,165	271,389	.178
6/12	17,081	100,406	117,487	388,876	.255
6/13	24,701	0	24,701	413,577	.271
6/14	24,062	77,283	101,345	514,922	.337
6/15	21,626	0	21,626	536,548	.351
6/16	12,017	82,666	94,683	631,231	.413
6/17	19,118	63,541	82,659	713,890	.468
6/18	46,112	4,440	50,552	764,442	.501
6/19	14,565	7,023	21,588	786,030	.515
6/20	5,750	85,075	90,825	876,855	.574
6/21	11,727	60,355	72,082	948,937	.622
6/22	20,280	28,506	48,786	997,723	.654
6/23	3,540	41,815	45,355	1,043,078	.683
6/24	6,502	21,459	27,961	1,071,039	.702
6/25	12,119	20,670	32,789	1,103,828	.723
6/26	7,916	55,030	62,946	1,166,774	.764
6/27	3,130	27,594	30,724	1,197,498	.784
6/28	1,877	21,650	23,527	1,221,025	.800
6/29	1,158	12,327	13,485	1,234,510	.809
6/30	1,469	19,066	20,535	1,255,045	.822
7/ 1	2,191	2,393	4,584	1,259,629	.825
7/ 2	1,350	20,580	21,930	1,281,559	.839
7/ 3	573	12,432	13,005	1,294,564	.848
7/ 4	940	4,031	4,971	1,299,535	.851
7/ 5	1,295	467	1,762	1,301,297	.852
7/ 6	572	28,454	29,026	1,330,323	.871
7/ 7	693	566	1,259	1,331,582	.872
7/ 8	560	26,772	27,332	1,358,914	.890
7/ 9	1,618	1,282	2,900	1,361,814	.892
7/10	3,603	1,093	4,696	1,366,510	.895
7/11	2,515	0	2,515	1,369,025	.897
7/12	1,394	42,646	44,040	1,413,065	.926
7/13	954	64	1,018	1,414,083	.926
7/14	2,269	1,182	3,451	1,417,534	.929
7/15	931	273	1,204	1,418,738	.929
7/16	4,903	38	4,941	1,423,679	.933
7/17	10,342	0	10,342	1,434,021	.939
7/18	3,714	1,123	4,837	1,438,858	.943
7/19	1,706	62,723	64,429	1,503,287	.985
7/20	2,186	31	2,217	1,505,504	.986
7/21	3,880	3,078	6,958	1,512,462	.991
After 7/21	2,605	11,537	14,142	1,526,604	1.000
Total	458,660	1,067,944	1,526,604		

Appendix Table 3e. Summary of the daily and cumulative return of sockeye salmon for the Chginik Lake stock in 1978.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/15	3,063	4,930	7,993	7,993	.008
6/15	430	0	430	8,423	.009
6/16	248	1,709	1,957	10,380	.011
6/17	408	1,356	1,764	12,144	.012
6/18	1,384	134	1,518	13,662	.014
6/19	581	280	861	14,523	.015
6/20	295	4,349	4,644	19,167	.020
6/21	932	4,800	5,732	24,899	.025
6/22	2,234	3,140	5,374	30,273	.031
6/23	508	5,989	6,497	36,770	.038
6/24	1,113	3,674	4,787	41,557	.043
6/25	2,477	4,224	6,701	48,258	.049
6/26	1,926	13,387	15,313	63,571	.065
6/27	904	7,974	8,878	72,449	.074
6/28	1,058	12,184	13,242	85,691	.088
6/29	789	8,399	9,188	94,879	.097
6/30	1,204	15,620	16,824	111,703	.114
7/ 1	2,004	2,186	4,190	115,893	.119
7/ 2	1,374	20,941	22,315	138,208	.141
7/ 3	651	14,095	14,746	152,954	.157
7/ 4	1,232	5,274	6,506	159,460	.163
7/ 5	1,963	705	2,668	162,128	.166
7/ 6	1,006	50,150	51,156	213,284	.218
7/ 7	1,221	998	2,219	215,503	.221
7/ 8	994	47,321	48,315	263,818	.270
7/ 9	2,924	2,318	5,242	269,060	.275
7/10	6,657	2,019	8,676	277,736	.284
7/11	4,751	0	4,751	282,487	.289
7/12	2,698	82,416	85,114	367,601	.376
7/13	1,908	130	2,038	369,639	.378
7/14	4,709	2,451	7,160	376,799	.386
7/15	2,003	590	2,593	379,392	.388
7/16	10,943	84	11,027	390,419	.400
7/17	23,961	0	23,961	414,380	.424
7/18	8,940	2,706	11,646	426,026	.436
7/19	4,266	156,840	161,106	587,132	.601
7/20	6,226	88	6,314	593,446	.607
7/21	12,689	10,063	22,752	616,198	.631
7/22	6,744	5,402	12,146	628,344	.643
7/23	1,942	44,457	46,399	674,743	.691
7/24	3,919	1,750	5,669	680,412	.696
7/25	4,362	41,464	45,826	726,238	.743
7/26	6,240	23,905	30,145	756,383	.774
7/27	6,894	7,193	14,087	770,470	.789
7/28	3,954	21,309	25,263	795,733	.814
7/29	5,856	5,132	10,988	806,721	.826
7/30	5,450	3,433	8,883	815,604	.835
7/31	2,520	7,785	10,305	825,909	.845
8/ 1	1,932	5,793	7,725	833,634	.853
8/ 2	1,278	6,923	8,201	841,835	.862
8/ 3	1,800	5,844	7,644	849,479	.869
8/ 4	972	6,319	7,291	856,770	.877
8/ 5	2,832	2,357	5,189	861,959	.882
8/ 6	5,124	1,791	6,915	868,874	.889
8/ 7	4,386	7,494	11,880	880,754	.901
8/ 8	1,662	4,704	6,366	887,120	.908
8/ 9	1,596	5,121	6,717	893,837	.915
After 8/ 9	31,750	51,409	83,159	976,996	1.000
Total	223,887	753,109	976,996		

Appendix Table 4a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1979.

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
5/22	0	0	0	0	0	0	0	0	0	0
5/23	0	0	0	0	0	0	0	0	0	0
5/24	0	0	0	0	0	0	0	0	0	0
5/25	0	0	0	0	0	0	0	0	0	0
5/26	0	0	0	0	0	0	0	0	0	0
5/27	0	0	0	0	0	0	0	0	0	0
5/28	1,000 [1]	0	0	0	0	0	0	0	0	1,000
5/29	1,000 [1]	0	0	0	0	0	0	0	0	1,000
5/30	1,000 [1]	0	0	0	0	0	0	0	0	1,000
5/31	1,596	0	0	0	0	0	0	0	0	1,596
6/ 1	1,764	0	0	0	0	0	0	0	0	1,764
6/ 2	3,276	0	0	0	0	0	0	0	0	3,276
6/ 3	4,283	0	0	0	0	0	0	0	0	4,283
6/ 4	4,431	0	0	0	0	0	0	0	0	4,431
6/ 5	3,906	0	0	0	0	0	0	0	0	3,906
6/ 6	10,662	0	0	0	0	0	0	0	0	10,662
6/ 7	12,348	0	0	0	0	0	0	0	0	12,348
6/ 8	15,204	0	0	0	0	0	0	0	0	15,204
6/ 9	8,372	44,135	0	0	0	0	0	0	0	52,507
6/10	10,758	0	0	0	0	0	0	0	0	10,758
6/11	16,930	0	0	2,706	0	0	0	0	0	19,636
6/12	24,836	0	0	0	0	0	0	0	0	24,836
6/13	14,562	0	0	0	0	0	0	0	0	14,562
6/14	18,218	0	0	0	0	7,346	0	0	0	25,564
6/15	23,604	0	0	0	0	0	0	0	0	23,604
6/16	16,882	0	0	0	0	0	0	0	0	16,882
6/17	26,526	0	0	0	0	0	0	0	0	26,526
6/18	21,493	0	0	0	0	0	0	0	0	21,493
6/19	20,118	0	0	0	0	0	0	0	0	20,118
6/20	21,456	0	0	0	0	0	0	0	0	21,456
6/21	21,766	0	0	0	0	0	0	0	0	21,766
6/22	10,862	0	0	0	0	0	0	0	0	10,862
6/23	8,798	0	0	0	0	0	0	0	0	8,798
6/24	12,270	0	0	0	0	0	0	0	0	12,270
6/25	10,237	0	0	0	0	0	0	0	0	10,237

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Appendix Table 4a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1979 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
6/26	13,894	0	0	0	0	0	0	0	0	13,894
6/27	12,610	0	0	0	0	0	0	0	0	12,610
6/28	8,036	0	0	0	0	0	0	0	0	8,036
6/29	8,351	0	0	0	0	0	0	0	0	8,351
6/30	21,746	0	0	0	0	0	0	0	0	21,746
7/ 1	9,659	0	0	0	0	0	0	0	0	9,659
7/ 2	27,554	0	0	0	0	0	0	0	0	27,554
7/ 3	14,827	0	0	0	0	0	0	0	0	14,827
7/ 4	6,660	0	0	0	0	0	0	0	0	6,660
7/ 5	8,817	0	0	0	0	0	0	0	0	8,817
7/ 6	10,000	1,776	0	0	0	0	0	0	0	11,776
7/ 7	8,000	91,617	0	0	0	0	0	0	0	99,617
7/ 8	8,000	41,084	366	0	0	0	4,811	0	0	54,261
7/ 9	15,048	3,561	136	0	0	0	1,985	0	0	20,730
7/10	25,457	947	200	2,451	0	0	934	0	0	29,989
7/11	61,810	0	0	0	0	0	389	84	0	62,283
7/12	18,298	79,976	0	0	0	0	0	0	0	98,274
7/13	4,212	64,627	0	0	0	0	0	0	0	68,839
7/14	3,066	54,870	0	0	0	0	0	0	0	57,936
7/15	18,856	209	2,824	6,530	0	0	0	0	0	28,419
7/16	4,332	48,582	0	6,909	0	0	0	0	0	59,823
7/17	3,438	41,534	2,047	0	0	0	0	0	0	47,019
7/18	2,904	39,636	5,799	3,613	0	0	0	0	0	51,952
7/19	1,542	33,394	9,408	6,800	0	0	102	0	0	51,246
7/20	1,494	27,435	1,532	5,663	0	0	0	447	0	36,571
7/21	3,156	22,615	2,832	9,451	0	0	1,130	966	0	40,150
7/22	2,532	19,882	2,169	12,720	0	0	100	0	0	37,403
7/23	1,992	26,373	927	5,779	0	0	0	0	0	35,071
7/24	3,284	17,173	0	5,639	0	0	0	0	0	26,096
7/25	978	24,106	0	0	0	0	907	0	0	25,991
7/26	1,590	22,771	0	0	0	0	763	18	0	25,142
7/27	1,590	23,159	0	0	0	1,550	1,155	8	0	27,462
7/28	1,086	16,394	0	0	0	5,200	0	21	0	22,701
7/29	1,614	10,998	0	0	0	667	0	0	0	13,279
7/30	3,222	12,060	0	0	0	226	0	0	0	15,508

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Appendix Table 4a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1979 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
7/31	1,613[2]	9,940	540	0	0	0	0	0	0	12,093
8/ 1	1,613	8,994	1,873	1,271	0	0	642	0	0	14,393
8/ 2	1,613	10,268	751	3,166	0	0	1,202	119	0	17,119
8/ 3	1,613	7,301	1,640	2,038	0	0	2,709	16	0	15,317
8/ 4	1,613	0	121	406	0	0	1,875	0	0	4,015
8/ 5	1,613	0	0	1,114	0	0	96	184	0	3,007
8/ 6	1,613	11,919	0	0	0	0	0	13	0	13,545
8/ 7	1,613	8,689	1,186	0	0	0	0	0	0	11,488
8/ 8	1,613	7,404	1,097	1,904	0	0	296	0	0	12,314
8/ 9	1,613	5,716	380	1,150	170	0	365	53	0	9,447
8/10	1,613	7,238	0	1,005	25	0	326	128	0	10,335
8/11	1,613	0	250	0	7	0	375	121	0	2,366
8/12	1,613	0	39	0	0	0	0	2	0	1,654
8/13	1,613	9,097	0	108	0	0	0	0	0	10,818
8/14	1,613	4,145	0	0	0	0	119	0	0	5,877
8/15	1,613	6,018	0	137	0	0	30	5	0	7,803
8/16	1,613	3,231	0	13	0	0	0	92	0	4,949
8/17	1,613	6,328	0	44	0	0	1	65	0	8,051
8/18	1,613	0	514	0	0	0	0	166	0	2,293
8/19	1,613	0	0	0	0	0	0	36	0	1,649
8/20	1,613	8,287	0	0	0	0	0	156	0	10,056
8/21	1,613	4,286	0	0	0	0	0	0	0	5,899
8/22	1,613	4,400	0	0	0	0	1	0	0	6,014
8/23	1,613	4,576	0	0	0	0	0	0	0	6,189
8/24	1,613	3,474	0	0	0	0	0	0	0	5,087
8/25	1,613	0	0	0	0	0	0	0	0	1,613
8/26	1,613	0	0	0	0	0	0	0	0	1,613
8/27	1,613	2,617	0	0	0	0	0	0	0	4,230
8/28	1,613	1,452	0	0	0	0	0	0	0	3,065
8/29	1,613	1,271	0	0	0	0	0	0	0	2,884
8/30	1,613	1,673	0	0	0	0	6	148	0	3,440
8/31	0	947	0	0	0	0	0	0	0	947
9/ 1	0	0	0	0	0	0	0	0	0	0
9/ 2	0	0	0	0	0	0	0	6	0	6
9/ 3	0	0	0	0	0	0	0	7	0	7

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Appendix Table 4a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1979 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
9/ 4	0	0	0	0	0	0	0	0	0	0
9/ 5	0	0	0	0	0	0	0	0	0	0
9/ 6	0	0	0	0	0	0	0	1	0	1
9/ 7	0	0	0	0	0	0	0	0	0	0
9/ 8	0	0	0	0	0	0	0	4	0	4
9/ 9	0	0	0	0	0	0	0	0	0	0
9/10	0	0	0	0	0	0	0	0	0	0
9/11	0	96	0	0	0	0	0	0	0	96
9/12	0	10	0	0	0	0	0	0	0	10
9/13	0	29	0	0	0	0	0	0	0	29
9/14	0	0	0	0	0	0	0	0	0	0
9/15	0	0	0	0	0	0	0	0	0	0
9/16	0	62	0	0	0	0	0	0	0	62
9/17	0	23	0	0	0	0	0	0	0	23
9/18	0	0	0	0	0	0	0	0	0	0
9/19	0	0	0	0	0	0	0	0	0	0
9/20	0	0	0	0	0	0	0	0	0	0
9/21	0	0	0	0	0	0	0	0	0	0
9/22	0	0	0	0	0	0	0	0	0	0
9/23	0	0	0	0	0	0	0	0	0	0
9/24	0	0	0	0	0	0	0	0	0	0
9/25	0	0	0	0	0	0	0	0	0	0
9/26	0	0	0	0	0	0	0	0	0	0
9/27	0	0	0	0	0	0	0	0	0	0
9/28	0	0	0	0	0	0	0	0	0	0
9/29	0	0	0	0	0	0	0	0	0	0
9/30	0	0	0	0	0	0	0	0	0	0
Total	737,816	908,405	36,631	80,617	202	14,989	20,319	2,866	0	1,801,845[3]

[1] Escapement estimated.

[2] Prorated for an estimated escapement of 50,000 in August.

[3] Does not include the Stepovak catch of 64,400 for which there were no daily estimates.

Appendix Table 4b. Age composition of sockeye salmon scale samples collected in Chignik Lagoon during 1979, by percent of sample.

Sample Date	Sample Size	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/ 6	79	0.0	0.0	1.3	5.0	0.0	40.5	53.2	0.0	0.0	0.0	0.0
6/ 9	226	.4	0.0	4.0	10.6	.4	39.4	45.2	0.0	0.0	0.0	0.0
6/16	174	0.0	.6	4.6	15.5	0.0	39.1	39.6	0.0	0.0	.6	0.0
6/27	124	0.0	0.0	2.4	23.4	0.0	29.0	43.6	1.6	0.0	0.0	0.0
7/ 3	166	0.0	0.0	1.2	14.5	.6	12.6	70.5	.6	0.0	0.0	0.0
7/ 7	411	0.0	.3	2.7	9.7	.3	8.0	78.8	.2	0.0	0.0	0.0
7/ 8	381	0.0	0.0	2.6	8.2	0.0	4.2	84.5	.5	0.0	0.0	0.0
7/13	651	.1	.3	2.0	11.7	.5	4.0	81.1	.3	0.0	0.0	0.0
7/16	550	0.0	.7	2.9	15.4	.2	2.0	78.4	.4	0.0	0.0	0.0
7/18	630	.3	.2	3.8	17.4	.5	2.4	75.2	.2	0.0	0.0	0.0
7/20	303	0.0	1.0	.3	26.1	0.0	2.6	69.0	1.0	0.0	0.0	0.0
7/22	606	0.0	.3	3.5	24.9	.2	1.1	69.8	.2	0.0	0.0	0.0
7/26	650	0.0	2.8	1.1	30.6	.1	2.6	62.3	.5	0.0	0.0	0.0
7/29	108	0.0	0.0	0.0	18.5	.9	1.9	78.7	0.0	0.0	0.0	0.0
8/ 2	73	0.0	1.4	1.4	23.3	0.0	2.7	71.2	0.0	0.0	0.0	0.0
8/13	119	0.0	0.0	.8	20.2	.8	2.5	75.7	0.0	0.0	0.0	0.0
8/31	129	1.5	1.6	.8	36.4	.8	9.3	49.6	0.0	0.0	0.0	0.0

Appendix Table 4c. Age composition of sockeye salmon scale samples collected at Black Lake outlet during 1979, by percent of sample.

Sample Date	Sample Size	Age										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/19	93	1.1	0.0	2.1	11.8	0.0	32.3	51.6	0.0	0.0	1.1	0.0
6/24	345	0.0	0.0	3.5	7.8	0.0	40.6	48.1	0.0	0.0	0.0	0.0
6/26	230	0.0	0.0	3.0	8.3	0.0	25.7	63.0	0.0	0.0	0.0	0.0
6/27	373	.5	.3	2.9	8.0	0.0	34.9	52.8	0.0	0.0	.3	.3
6/28	356	.6	0.0	2.8	9.5	0.0	28.9	57.9	0.0	0.0	0.0	.3
Mean		0.44	0.06	2.86	9.08	0.0	32.48	54.68	0.0	0.0	0.28	0.12

Appendix Table 4d. Summary of the daily and cumulative return of sockeye salmon for the Black Lake stock in 1979.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/ 1	4,439	0	4,439	4,439	.008
6/ 1	1,622	0	1,622	6,061	.011
6/ 2	2,945	0	2,945	9,006	.016
6/ 3	3,765	0	3,765	12,771	.022
6/ 4	3,806	0	3,806	16,577	.029
6/ 5	3,275	0	3,275	19,852	.034
6/ 6	8,728	0	8,728	28,580	.050
6/ 7	9,757	0	9,757	38,337	.066
6/ 8	11,574	0	11,574	49,911	.087
6/ 9	6,123	32,278	38,401	88,312	.153
6/10	7,925	0	7,925	96,237	.167
6/11	12,557	2,007	14,564	110,801	.192
6/12	18,560	0	18,560	129,361	.224
6/13	10,964	0	10,964	140,325	.243
6/14	13,822	5,573	19,395	159,720	.277
6/15	18,050	0	18,050	177,770	.308
6/16	13,300	0	13,300	191,070	.331
6/17	20,535	0	20,535	211,605	.367
6/18	16,347	0	16,347	227,952	.395
6/19	15,029	0	15,029	242,981	.421
6/20	15,738	0	15,738	258,719	.448
6/21	15,675	0	15,675	274,394	.476
6/22	7,678	0	7,678	282,072	.489
6/23	6,100	0	6,100	288,172	.499
6/24	8,347	0	8,347	296,519	.514
6/25	6,828	0	6,828	303,347	.526
6/26	9,086	0	9,086	312,433	.541
6/27	8,083	0	8,083	320,516	.556
6/28	5,031	0	5,031	325,547	.564
6/29	5,080	0	5,080	330,627	.573
6/30	12,777	0	12,777	343,404	.595
7/ 1	5,447	0	5,447	348,851	.605
7/ 2	14,814	0	14,814	363,665	.630
7/ 3	7,538	0	7,538	371,203	.643
7/ 4	3,108	0	3,108	374,311	.649
7/ 5	3,735	0	3,735	378,046	.655
7/ 6	3,794	673	4,467	382,513	.663
7/ 7	2,674	30,623	33,297	415,810	.721
7/ 8	2,230	12,895	15,125	430,935	.747
7/ 9	4,044	1,527	5,571	436,506	.757
7/10	6,524	1,162	7,686	444,192	.770
7/11	15,038	115	15,153	459,345	.796
7/12	4,210	18,393	22,603	481,948	.835
7/13	910	13,980	14,890	496,838	.861
7/14	630	11,267	11,897	508,735	.882
7/15	3,646	1,849	5,495	514,230	.891
7/16	781	10,004	10,785	525,015	.910
7/17	608	7,701	8,309	533,324	.924
7/18	501	8,468	8,969	542,293	.940
7/19	282	9,107	9,389	551,682	.956
7/20	289	6,794	7,083	558,765	.968
7/21	523	6,125	6,648	565,413	.980
7/22	348	4,799	5,147	570,560	.989
7/23	208	3,455	3,663	574,223	.995
7/24	231	1,606	1,837	576,060	.998
7/25	35	890	925	576,985	1.000
After 7/25	0	0	0	576,985	1.000
Total	385,694	191,291	576,985		

Appendix Table 4e. Summary of the daily and cumulative return of sockeye salmon for the Chignik Lake stock in 1979.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/17	43,420	14,329	57,749	57,749	.047
6/17	5,991	0	5,991	63,740	.052
6/18	5,146	0	5,146	68,886	.056
6/19	5,089	0	5,089	73,975	.060
6/20	5,718	0	5,718	79,693	.065
6/21	6,091	0	6,091	85,784	.070
6/22	3,184	0	3,184	88,968	.073
6/23	2,698	0	2,698	91,666	.075
6/24	3,923	0	3,923	95,589	.078
6/25	3,409	0	3,409	98,998	.081
6/26	4,808	0	4,808	103,806	.085
6/27	4,527	0	4,527	108,333	.088
6/28	3,005	0	3,005	111,338	.091
6/29	3,271	0	3,271	114,609	.094
6/30	8,969	0	8,969	123,578	.101
7/ 1	4,212	0	4,212	127,790	.104
7/ 2	12,740	0	12,740	140,530	.115
7/ 3	7,289	0	7,289	147,819	.121
7/ 4	3,552	0	3,552	151,371	.124
7/ 5	5,082	0	5,082	156,453	.128
7/ 6	6,206	1,103	7,309	163,762	.134
7/ 7	5,326	60,994	66,320	230,082	.188
7/ 8	5,770	33,366	39,136	269,218	.220
7/ 9	11,004	4,155	15,159	284,377	.232
7/10	18,933	3,370	22,303	306,680	.250
7/11	46,772	358	47,130	353,810	.289
7/12	14,088	61,583	75,671	429,481	.351
7/13	3,302	50,647	53,949	483,430	.395
7/14	2,436	43,603	46,039	529,469	.432
7/15	15,210	7,714	22,924	552,393	.451
7/16	3,551	45,487	49,038	601,431	.491
7/17	2,830	35,880	38,710	640,141	.523
7/18	2,403	40,580	42,983	683,124	.558
7/19	1,260	40,597	41,857	724,981	.592
7/20	1,205	28,283	29,488	754,469	.616
7/21	2,633	30,869	33,502	787,971	.643
7/22	2,184	30,072	32,256	820,227	.670
7/23	1,784	29,624	31,408	851,635	.695
7/24	3,053	21,206	24,259	875,894	.715
7/25	943	24,123	25,066	900,960	.736
7/26	1,590	23,552	25,142	926,102	.756
7/27	1,590	25,872	27,462	953,564	.779
7/28	1,086	21,615	22,701	976,265	.797
7/29	1,614	11,665	13,279	989,544	.808
7/30	3,222	12,286	15,508	1,005,052	.821
7/31	1,613	10,480	12,093	1,017,145	.830
8/ 1	1,613	12,780	14,393	1,031,538	.842
8/ 2	1,613	15,506	17,119	1,048,657	.856
8/ 3	1,613	13,704	15,317	1,063,974	.869
8/ 4	1,613	2,402	4,015	1,067,989	.872
8/ 5	1,613	1,394	3,007	1,070,996	.874
8/ 6	1,613	11,932	13,545	1,084,541	.885
8/ 7	1,613	9,875	11,488	1,096,029	.895
8/ 8	1,613	10,701	12,314	1,108,343	.905
8/ 9	1,613	7,834	9,447	1,117,790	.913
8/10	1,613	8,722	10,335	1,128,125	.921
8/11	1,613	753	2,366	1,130,491	.923
8/12	1,613	41	1,654	1,132,145	.924
After 8/12	29,034	63,681	92,715	1,224,860	1.000
Total	352,122	872,738	1,224,860		

Appendix Table 5a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1980.

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
5/22	0	0	0	0	0	0	0	0	0	0
5/23	0	0	0	0	0	0	0	0	0	0
5/24	0	0	0	0	0	0	0	0	0	0
5/25	0	0	0	0	0	0	0	0	0	0
5/26	0	0	0.	0	0	0	0	0	0	0
5/27	0	0	0	0	0	0	0	0	0	0
5/28	0	0	0	0	0	0	0	0	0	0
5/29	0	0	0	0	0	0	0	0	0	0
5/30	1,230	0	0	0	0	0	0	0	0	1,230
5/31	94	0	0	0	0	0	0	0	0	94
6/ 1	72	0	0	0	0	0	0	0	0	72
6/ 2	42	0	0	0	0	0	0	0	0	42
6/ 3	100[1]	0	0	0	0	0	0	0	0	100
6/ 4	300[1]	0	0	0	0	0	0	0	0	300
6/ 5	500[1]	0	0	0	0	0	0	0	0	500
6/ 6	1,000[1]	0	0	0	0	0	0	0	0	1,000
6/ 7	2,000[1]	0	0	0	0	0	0	0	0	2,000
6/ 8	3,000[1]	0	0	0	0	0	0	0	0	3,000
6/ 9	4,000[1]	0	0	0	0	0	0	0	0	4,000
6/10	4,000[1]	0	0	0	0	0	0	0	0	4,000
6/11	5,000[1]	0	0	0	0	0	0	0	0	5,000
6/12	5,000[1]	0	0	0	0	0	0	0	0	5,000
6/13	12,180	0	0	0	0	0	0	0	0	12,180
6/14	8,853	0	0	0	0	0	0	0	0	8,853
6/15	5,340	0	0	0	0	0	0	0	0	5,340
6/16	22,858	0	0	0	0	0	0	0	0	22,858
6/17	38,801	0	0	0	0	0	0	0	0	38,801
6/18	29,690	0	0	0	0	0	0	0	0	29,690
6/19	27,071	0	0	0	0	0	0	0	0	27,071
6/20	17,499	0	0	0	0	0	0	0	0	17,499
6/21	16,266	0	0	0	0	0	0	0	0	16,266
6/22	1,884	0	0	0	0	0	0	0	0	1,884
6/23	10,000	0	0	0	0	0	0	0	0	10,000
6/24	9,656	295	0	0	0	0	0	0	0	9,951
6/25	10,499	0	0	0	0	0	0	0	0	10,499

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Appendix Table 5a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1980 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
6/26	6,214	0	0	0	0	0	0	0	0	6,214
6/27	17,939	0	0	0	0	0	0	0	0	17,939
6/28	14,226	0	0	0	0	0	0	0	0	14,226
6/29	8,344	0	0	0	0	0	0	0	0	8,344
6/30	7,268	0	0	0	0	0	0	0	0	7,268
7/ 1	26,737	322	0	0	0	0	0	0	0	27,059
7/ 2	46,469	0	0	0	0	0	0	0	0	46,469
7/ 3	14,026	0	0	0	0	0	0	0	0	14,026
7/ 4	15,086	0	0	0	0	0	0	0	0	15,086
7/ 5	24,259	357	0	0	0	0	0	0	0	24,616
7/ 6	20,937	0	0	0	0	0	0	0	0	20,937
7/ 7	21,343	0	0	0	0	0	0	0	0	21,343
7/ 8	64,743	0	0	0	0	0	0	0	0	64,743
7/ 9	20,177	78,690	0	0	0	0	0	0	0	98,867
7/10	10,326	84,467	3,705	0	0	0	0	0	0	98,498
7/11	5,526	46,519	735	2,551	0	0	0	0	0	55,331
7/12	3,306	49,123	8,783	635	0	0	0	0	0	61,847
7/13	4,650	31,277	19,196	2,069	0	0	0	0	0	57,192
7/14	6,138	36,028	2,883	4,893	0	0	0	0	0	49,942
7/15	2,736	31,920	2,272	4,312	0	0	0	0	0	41,240
7/16	1,000	30,977	225	520	0	0	0	0	0	32,722
7/17	2,832	28,457	4,150	9,828	0	0	0	0	0	45,267
7/18	3,322	25,599	4,687	6,162	0	0	2,105	0	0	41,875
7/19	2,578	23,371	142	4,316	400	0	723	0	0	31,530
7/20	1,194	20,593	4,654	2,421	0	0	5	0	0	28,867
7/21	1,044	16,979	2,921	2,433	0	0	0	0	0	23,377
7/22	1,446	13,989	1,401	2,594	0	0	0	0	0	19,430
7/23	1,640	10,296	2,031	5,064	0	0	0	0	0	19,031
7/24	2,298	9,523	575	4,327	0	0	0	0	0	16,723
7/25	3,050	11,507	0	2,120	0	0	106	0	0	16,783
7/26	4,270	227	0	0	0	0	1,096	0	0	5,593
7/27	5,844	402	0	0	0	0	1,097	591	0	7,934
7/28	2,156	8,928	0	0	0	0	603	984	0	12,671
7/29	1,840	7,616	885	0	0	0	323	728	0	11,392
7/30	2,159	7,863	1,404	1,290	0	449	390	422	0	13,977

-Continued-

Appendix Table 5a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1980 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
7/31	1,613[2]	8,885	704	1,190	0	0	0	211	0	12,603
8/ 1	1,613	9,686	469	478	0	0	44	0	0	12,290
8/ 2	1,613	75	196	1,221	0	0	0	179	0	3,284
8/ 3	1,613	0	0	1,198	0	0	1	0	0	2,812
8/ 4	1,613	11,816	0	0	0	0	0	0	0	13,429
8/ 5	1,613	6,744	842	0	0	0	14	0	0	9,213
8/ 6	1,613	3,658	1,282	673	0	0	576	0	0	7,802
8/ 7	1,613	4,150	927	690	0	0	321	506	0	8,207
8/ 8	1,613	3,382	1,767	521	0	0	251	327	0	7,861
8/ 9	1,613	0	679	319	0	0	6	154	0	2,771
8/10	1,613	274	0	343	180	0	0	89	0	2,499
8/11	1,613	8,622	0	31	97	0	0	0	0	10,363
8/12	1,613	3,545	458	0	173	0	0	0	0	5,789
8/13	1,613	3,835	37	348	11	0	0	0	0	5,844
8/14	1,613	4,298	1,167	175	19	0	679	0	0	7,951
8/15	1,613	3,835	1,072	233	0	0	204	266	0	7,223
8/16	1,613	679	110	220	13	0	334	823	0	3,792
8/17	1,613	0	0	129	9	0	174	539	0	2,464
8/18	1,613	4,768	0	0	12	0	60	517	0	6,970
8/19	1,613	6,276	58	0	0	0	0	0	0	7,947
8/20	1,613	7,964	253	0	0	0	38	0	0	9,868
8/21	1,613	5,888	309	0	0	0	0	0	0	7,810
8/22	1,613	3,612	163	0	0	0	0	0	0	5,388
8/23	1,613	0	7	0	0	0	0	0	0	1,620
8/24	1,613	303	0	0	0	0	0	0	0	1,916
8/25	1,613	5,239	0	11	0	0	0	0	0	6,863
8/26	1,613	3,970	0	58	0	0	0	0	0	5,641
8/27	1,613	3,490	0	75	1	0	9	0	0	5,188
8/28	1,613	2,794	0	24	6	0	0	0	0	4,437
8/29	1,613	4,091	0	0	2	0	65	0	0	5,771
8/30	1,613	0	0	27	4	0	0	0	0	1,644
8/31	0	0	0	0	0	0	3	0	0	3
9/ 1	0	1,985	0	0	0	0	0	0	0	1,985
9/ 2	0	1,562	0	0	0	0	0	0	0	1,562
9/ 3	0	824	0	0	0	0	0	0	0	824

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Appendix Table 5a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1980 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
9/ 4	0	0	0	0	0	0	0	0	0	0
9/ 5	0	0	0	0	0	0	0	0	0	0
9/ 6	0	0	0	0	0	0	0	0	0	0
9/ 7	0	0	0	0	0	0	0	0	0	0
9/ 8	0	2,817	0	0	0	0	0	0	0	2,817
9/ 9	0	2,116	0	0	0	0	0	0	0	2,116
9/10	0	1,396	0	0	0	0	0	0	0	1,396
9/11	0	238	0	0	0	0	0	0	0	238
9/12	0	475	0	0	0	0	0	0	0	475
9/13	0	150	0	0	0	0	0	0	0	150
9/14	0	61	0	0	0	0	0	0	0	61
9/15	0	0	0	0	0	0	0	0	0	0
9/16	0	0	0	0	0	0	0	0	0	0
9/17	0	0	0	0	0	0	0	0	0	0
9/18	0	0	0	0	0	0	0	0	0	0
9/19	0	0	0	0	0	0	0	0	0	0
9/20	0	0	0	0	0	0	0	0	0	0
9/21	0	0	0	0	0	0	0	0	0	0
9/22	0	0	0	0	0	0	0	0	0	0
9/23	0	0	0	0	0	0	0	0	0	0
9/24	0	0	0	0	0	0	0	0	0	0
9/25	0	0	0	0	0	0	0	0	0	0
9/26	0	0	0	0	0	0	0	0	0	0
9/27	0	0	0	0	0	0	0	0	0	0
9/28	0	0	0	0	0	0	0	0	0	0
9/29	0	0	0	0	0	0	0	0	0	0
9/30	0	0	0	0	0	0	0	0	0	0
Total	664,061	708,828	71,149	63,499	927	449	9,277	6,366	0	1,524,476[3]

[1] Escapement estimated.

[2] Prorated for an estimated escapement of 50,000 in August.

[3] Does not include the Stepovak catch of 98,247 for which there were no daily estimates.

Appendix Table 5b. Age composition of sockeye salmon scale samples collected in Chignik Lagoon during 1980, by percent of sample.

Sample Date	Sample Size	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/ 6	70	0.0	0.0	12.9	5.7	0.0	38.6	41.4	0.0	1.4	0.0	0.0
6/ 8	135	0.0	0.0	11.9	3.7	0.0	42.2	40.8	0.0	0.0	.7	.7
6/11	113	.9	0.0	8.8	1.8	0.0	38.9	46.0	0.0	.9	0.0	2.7
6/13	150	0.0	0.0	15.3	4.7	0.0	37.3	42.7	0.0	0.0	0.0	0.0
6/17	101	0.0	0.0	9.9	2.0	0.0	34.6	52.5	0.0	0.0	0.0	1.0
6/23	163	0.0	0.0	21.5	4.9	0.0	35.0	36.8	0.0	0.0	0.0	1.8
7/ 1	134	0.0	0.0	14.9	9.0	0.0	14.9	61.2	0.0	0.0	0.0	0.0
7/ 5	119	0.0	0.0	7.6	4.2	0.0	12.6	74.8	.8	0.0	0.0	0.0
7/10	245	0.0	0.0	3.3	4.9	.4	7.8	82.0	.8	0.0	.4	.4
7/11	261	0.0	0.0	6.1	12.3	0.0	6.5	74.7	0.0	0.0	0.0	.4
7/13	318	0.0	.3	6.0	17.3	.3	6.6	68.9	.6	0.0	0.0	0.0
7/15	242	0.0	0.0	2.9	24.8	0.0	8.7	61.1	2.1	0.0	0.0	.4
7/17	330	.3	0.0	4.2	19.1	.3	8.5	67.0	.3	0.0	0.0	.3
7/19	338	0.0	0.0	4.4	31.7	0.0	6.5	56.5	.3	0.0	.6	0.0
7/21	340	0.0	.3	6.5	34.7	.3	5.6	52.6	0.0	0.0	0.0	0.0
7/23	337	0.0	0.0	7.1	34.4	0.0	8.0	50.2	0.0	0.0	0.0	.3
7/29	236	0.0	.4	1.3	32.6	.9	5.9	58.5	.4	0.0	0.0	0.0
8/13	149	0.0	0.0	1.3	27.5	0.0	4.7	66.5	0.0	0.0	0.0	0.0
8/16	109	0.0	0.0	0.0	25.7	0.0	3.7	68.8	.9	0.0	.9	0.0
8/27	47	0.0	0.0	2.1	31.9	0.0	4.3	61.7	0.0	0.0	0.0	0.0

Appendix Table 5c. Age composition of sockeye salmon scale samples collected at Black Lake outlet during 1980, by percent of sample.

Sample Date	Sample Size	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/26	63	0.0	0.0	20.6	0.0	0.0	36.5	42.9	0.0	0.0	0.0	0.0
6/27	343	0.0	0.0	16.9	1.5	0.0	37.6	43.4	0.0	0.0	0.0	.6
6/29	312	.3	0.0	15.4	4.5	0.0	35.6	42.6	0.0	0.0	0.0	1.6
6/30	318	.3	0.0	17.0	3.2	0.0	37.7	40.6	0.0	0.0	.3	.9
7/ 2	154	0.0	0.0	17.5	1.9	0.0	37.0	41.6	0.0	0.0	0.0	2.0
7/ 3	177	0.0	0.0	27.1	3.4	0.0	35.0	34.5	0.0	0.0	0.0	0.0
Mean		0.10	0.22	19.08	2.42	0.0	36.57	40.93	0.0	0.0	0.05	0.12

Appendix Table 5d. Summary of the daily and cumulative return of sockeye salmon for the Black Lake stock in 1980.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/ 1	1,320	0	1,320	1,320	.003
6/ 1	66	0	66	1,386	.003
6/ 2	36	0	36	1,422	.003
6/ 3	83	0	83	1,505	.003
6/ 4	231	0	231	1,736	.004
6/ 5	363	0	363	2,099	.005
6/ 6	678	0	678	2,777	.006
6/ 7	1,234	0	1,234	4,011	.009
6/ 8	1,665	0	1,665	5,676	.012
6/ 9	2,352	0	2,352	8,028	.017
6/10	2,483	0	2,483	10,511	.023
6/11	3,260	0	3,260	13,771	.030
6/12	3,221	0	3,221	16,992	.036
6/13	7,745	0	7,745	24,737	.053
6/14	5,697	0	5,697	30,434	.065
6/15	3,475	0	3,475	33,909	.073
6/16	15,041	0	15,041	48,950	.105
6/17	25,798	0	25,798	74,748	.160
6/18	19,030	0	19,030	93,778	.201
6/19	16,680	0	16,680	110,458	.237
6/20	10,335	0	10,335	120,793	.259
6/21	9,175	0	9,175	129,968	.279
6/22	1,011	0	1,011	130,979	.281
6/23	5,086	0	5,086	136,065	.292
6/24	5,064	155	5,219	141,284	.303
6/25	5,648	0	5,648	146,932	.315
6/26	3,410	0	3,410	150,342	.323
6/27	9,995	0	9,995	160,337	.344
6/28	8,013	0	8,013	168,350	.361
6/29	4,729	0	4,729	173,079	.371
6/30	4,126	0	4,126	177,205	.380
7/ 1	15,139	183	15,322	192,527	.413
7/ 2	25,208	0	25,208	217,735	.467
7/ 3	7,269	0	7,269	225,004	.483
7/ 4	7,446	0	7,446	232,450	.499
7/ 5	11,363	167	11,530	243,980	.523
7/ 6	9,593	0	9,593	253,573	.544
7/ 7	9,554	0	9,554	263,127	.565
7/ 8	28,275	0	28,275	291,402	.625
7/ 9	8,584	33,481	42,065	333,467	.715
7/10	4,275	36,501	40,776	374,243	.803
7/11	1,585	14,282	15,867	390,110	.837
7/12	778	13,786	14,564	404,674	.868
7/13	1,057	11,936	12,993	417,667	.896
7/14	1,147	8,175	9,322	426,989	.916
7/15	408	5,744	6,152	433,141	.929
7/16	132	4,182	4,314	437,455	.939
7/17	318	4,765	5,083	442,538	.949
7/18	384	4,449	4,833	447,371	.960
7/19	315	3,549	3,864	451,235	.968
7/20	162	3,770	3,932	455,167	.977
7/21	155	3,347	3,502	458,669	.984
7/22	178	2,231	2,409	461,078	.989
7/23	161	1,713	1,874	462,952	.993
7/24	185	1,172	1,357	464,309	.996
After 7/24	611	1,172	1,783	466,092	1.000
Total	311,332	154,760	466,092		

Appendix Table 5e. Summary of the daily and cumulative return of sockeye salmon for the Chignik Lake stock in 1980.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/22	74,928	0	74,928	74,928	.071
6/22	873	0	873	75,801	.072
6/23	4,914	0	4,914	80,715	.076
6/24	4,592	140	4,732	85,447	.081
6/25	4,851	0	4,851	90,298	.085
6/26	2,804	0	2,804	93,102	.088
6/27	7,944	0	7,944	101,046	.095
6/28	6,213	0	6,213	107,259	.101
6/29	3,615	0	3,615	110,874	.105
6/30	3,142	0	3,142	114,016	.108
7/ 1	11,598	139	11,737	125,753	.119
7/ 2	21,261	0	21,261	147,014	.139
7/ 3	6,757	0	6,757	153,771	.145
7/ 4	7,640	0	7,640	161,411	.153
7/ 5	12,896	190	13,086	174,497	.165
7/ 6	11,344	0	11,344	185,841	.176
7/ 7	11,789	0	11,789	197,630	.187
7/ 8	36,468	0	36,468	234,098	.221
7/ 9	11,593	45,209	56,802	290,900	.275
7/10	6,051	51,671	57,722	348,622	.329
7/11	3,941	35,523	39,464	388,086	.367
7/12	2,528	44,755	47,283	435,369	.411
7/13	3,593	40,606	44,199	479,568	.453
7/14	4,991	35,629	40,620	520,188	.491
7/15	2,328	32,760	35,088	555,276	.525
7/16	868	27,540	28,408	583,684	.551
7/17	2,514	37,670	40,184	623,868	.589
7/18	2,938	34,104	37,042	660,910	.624
7/19	2,263	25,403	27,666	688,576	.651
7/20	1,032	23,903	24,935	713,511	.674
7/21	889	18,986	19,875	733,386	.693
7/22	1,268	15,753	17,021	750,407	.709
7/23	1,479	15,678	17,157	767,564	.725
7/24	2,113	13,253	15,366	782,930	.740
7/25	2,855	12,852	15,707	798,637	.755
7/26	4,069	1,260	5,329	803,966	.760
7/27	5,661	2,025	7,686	811,652	.767
7/28	2,124	10,352	12,476	824,128	.779
7/29	1,840	9,552	11,392	835,520	.789
7/30	2,159	11,818	13,977	849,497	.803
7/31	1,613	10,990	12,603	862,100	.815
8/ 1	1,613	10,677	12,290	874,390	.826
8/ 2	1,613	1,671	3,284	877,674	.829
8/ 3	1,613	1,199	2,812	880,486	.832
8/ 4	1,613	11,816	13,429	893,915	.845
8/ 5	1,613	7,600	9,213	903,128	.853
8/ 6	1,613	6,189	7,802	910,930	.861
8/ 7	1,613	6,594	8,207	919,137	.868
8/ 8	1,613	6,248	7,861	926,998	.876
8/ 9	1,613	1,158	2,771	929,769	.878
8/10	1,613	886	2,499	932,268	.881
8/11	1,613	8,750	10,363	942,631	.891
8/12	1,613	4,176	5,789	948,420	.896
8/13	1,613	4,231	5,844	954,264	.902
8/14	1,613	6,338	7,951	962,215	.909
8/15	1,613	5,610	7,223	969,438	.916
8/16	1,613	2,179	3,792	973,230	.920
After 8/16	22,582	62,572	85,154	1,058,384	1.000
Total	352,729	705,655	1,058,384		

Appendix Table 6a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1981.

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
5/22	0	0	0	0	0	0	0	0	0	0
5/23	0	0	0	0	0	0	0	0	0	0
5/24	36	0	0	0	0	0	0	0	0	36
5/25	0	0	0	0	0	0	0	0	0	0
5/26	54	0	0	0	0	0	0	0	0	54
5/27	318	0	0	0	0	0	0	0	0	318
5/28	911	0	0	0	0	0	0	0	0	911
5/29	1,834	0	0	0	0	0	0	0	0	1,834
5/30	7,773	0	0	0	0	0	0	0	0	7,773
5/31	11,207	0	0	0	0	0	0	0	0	11,207
6/ 1	10,409	0	0	0	0	0	0	0	0	10,409
6/ 2	25,358	0	0	0	0	0	0	0	0	25,358
6/ 3	38,460	0	0	0	0	0	0	0	0	38,460
6/ 4	61,204	0	0	0	0	0	0	0	0	61,204
6/ 5	90,963	0	0	0	0	0	0	0	0	90,963
6/ 6	72,937	438	0	0	0	0	0	0	0	73,375
6/ 7	31,832	0	0	0	0	0	0	0	0	31,832
6/ 8	3,055	106,260	0	0	0	0	0	0	0	109,315
6/ 9	5,926	56,508	0	0	0	0	0	0	0	62,434
6/10	3,386	64,258	9,385	3,101	0	0	0	0	0	80,130
6/11	1,993	47,797	2,050	8,457	0	0	0	0	0	60,297
6/12	2,882	44,932	6,913	9,474	0	0	0	0	0	64,201
6/13	23,332	520	5,635	5,061	0	0	0	0	0	34,548
6/14	50,423	603	1,317	11,041	0	0	0	0	0	63,384
6/15	5,698	51,337	0	8,581	0	0	0	0	0	65,616
6/16	817	37,820	5,191	0	0	0	0	0	0	43,828
6/17	751	27,263	7,926	2,768	0	0	0	0	0	38,708
6/18	4,320	29,484	11,725	4,510	0	16,773	0	0	0	66,812
6/19	4,374	19,953	9,506	2,978	0	10,931	0	0	0	47,742
6/20	12,992	0	3,018	6,119	0	0	0	0	0	22,129
6/21	18,758	0	0	3,338	0	12,230	0	0	0	34,326
6/22	26,765	0	0	0	0	15,027	0	0	0	41,792
6/23	8,162	0	604	0	0	19,430	0	0	0	28,196
6/24	1,332	50,766	0	0	0	19,252	0	0	0	71,350
6/25	7,187	0	5,885	0	0	25,596	0	0	0	38,668

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Appendix Table 6a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1981 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
6/26	22,805	0	0	9,923	0	0	0	0	0	32,728
6/27	25,828	0	0	0	0	0	0	0	0	25,828
6/28	19,876	360	0	0	0	0	0	0	0	20,236
6/29	25,489	0	0	0	0	0	0	0	0	25,489
6/30	23,822	0	0	0	0	0	0	0	0	23,822
7/ 1	20,826	46,814	0	0	0	0	0	0	0	67,640
7/ 2	7,713	35,343	6,588	0	0	0	0	0	0	49,644
7/ 3	6,978	44,816	1,611	4,590	0	0	0	0	0	57,995
7/ 4	17,196	0	5,322	1,170	0	0	0	3	0	23,691
7/ 5	8,580	54,263	0	3,827	0	0	0	7	0	66,677
7/ 6	2,646	39,733	9,207	0	0	16,794	0	329	0	68,709
7/ 7	1,745	45,641	4,869	3,356	0	16,350	10	308	0	72,279
7/ 8	1,507	40,276	5,790	4,641	0	13,365	0	0	0	65,579
7/ 9	1,603	43,662	5,226	4,444	0	27,708	0	0	0	82,643
7/10	1,790	41,354	12,885	3,086	0	54,930	1,321	0	0	115,366
7/11	2,439	32,309	13,877	4,606	0	0	753	0	0	53,984
7/12	1,530	22,874	15,115	0	0	0	0	0	0	39,519
7/13	1,374	30,343	23,259	2,754	0	0	0	0	0	57,730
7/14	1,962	38,184	19,024	4,949	0	0	0	0	0	64,119
7/15	3,963	17,771	7,310	3,281	0	0	0	0	0	32,325
7/16	2,632	23,360	12,672	5,051	0	0	0	0	0	43,715
7/17	2,476	17,170	21,860	5,328	0	0	187	0	0	47,021
7/18	9,177	0	6,539	3,974	0	3,902	2,257	0	0	25,849
7/19	9,174	4,501	0	741	0	8,920	1,175	172	0	24,683
7/20	1,824	22,485	411	0	0	9,960	156	25	0	34,861
7/21	2,454	12,836	7,346	464	0	2,977	0	0	0	26,077
7/22	3,006	11,960	5,501	4,540	0	3,394	0	0	0	28,401
7/23	2,928	7,917	4,152	5,678	0	0	0	0	0	20,675
7/24	1,410	6,923	3,377	1,330	0	0	0	0	0	13,040
7/25	1,365	6,822	2,012	972	213	0	0	0	0	11,384
7/26	1,932	5,128	1,771	748	0	2,331	0	0	0	11,910
7/27	1,632	9,117	3,183	3,439	21	1,468	0	67	0	18,927
7/28	1,573	10,711	1,680	1,236	26	1,209	0	0	0	16,435
7/29	2,424	9,953	2,245	1,573	366	134	0	0	0	16,695
7/30	2,321	10,468	2,091	1,734	0	1,002	0	0	0	17,616

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Appendix Table 6a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1981 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
7/31	1,613[1]	8,269	2,226	1,649	0	0	373	0	0	14,130
8/ 1	1,613	0	1,055	3,324	0	0	1,188	228	0	7,408
8/ 2	1,613	0	0	3,357	0	0	2,233	625	0	7,828
8/ 3	1,613	10,285	0	0	0	0	0	967	0	12,865
8/ 4	1,613	9,046	1,177	0	0	0	0	0	0	11,836
8/ 5	1,613	6,852	622	2,967	0	0	0	0	0	12,054
8/ 6	1,613	6,813	286	26	0	0	454	0	0	9,192
8/ 7	1,613	6,489	424	2,191	64	0	2,844	162	0	13,787
8/ 8	1,613	0	500	1,562	137	0	654	675	0	5,141
8/ 9	1,613	0	0	1,173	702	0	423	323	0	4,234
8/10	1,613	10,250	0	0	27	0	80	208	0	12,178
8/11	1,613	5,140	285	0	0	0	0	0	0	7,038
8/12	1,613	3,565	84	1,243	0	0	2	0	0	6,507
8/13	1,613	6,550	1,169	0	14	0	176	158	0	9,680
8/14	1,613	8,307	1,166	1,108	25	0	105	191	0	12,515
8/15	1,613	0	1,636	734	6	0	127	626	0	4,742
8/16	1,613	0	0	347	35	0	174	579	0	2,748
8/17	1,613	7,070	0	0	0	0	59	667	0	9,409
8/18	1,613	4,745	1,022	0	0	0	0	0	0	7,380
8/19	1,613	4,072	384	138	0	0	0	97	0	6,304
8/20	1,613	1,440	1,356	122	0	0	0	0	0	4,531
8/21	1,613	1,628	4	63	0	0	0	0	0	3,308
8/22	1,613	0	0	0	0	0	0	0	0	1,613
8/23	1,613	0	0	0	0	0	0	0	0	1,613
8/24	1,613	5,598	0	0	0	0	0	0	0	7,211
8/25	1,613	3,251	385	0	0	0	0	0	0	5,249
8/26	1,613	1,704	0	0	0	0	0	0	0	3,317
8/27	1,613	1,573	0	0	0	0	0	0	0	3,186
8/28	1,613	0	0	0	0	0	0	0	0	1,613
8/29	1,613	0	0	0	0	0	0	0	0	1,613
8/30	1,610	0	0	0	0	0	0	0	0	1,610
8/31	0	0	0	0	0	0	0	0	0	0
Total	831,449	1,343,680	287,859	172,867	1,636	283,683	14,751	6,417	0	2,942,342[2]

1 Prorated for an estimated escapement of 50,000 in August.

2 Does not include the Stepovak catch of 118,000 for which there were no daily estimates.

Appendix Table 6b. Age composition of sockeye salmon scale samples collected in Chignik Lagoon during 1981, by percent of sample.

Sample Date	Sample Size	Age										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/ 3	265	0.0	0.0	3.8	.4	0.0	88.3	7.1	0.0	0.0	0.0	.4
6/ 8	288	0.0	0.0	6.9	1.4	0.0	79.9	9.0	0.0	0.0	0.0	2.8
6/11	289	0.0	0.0	7.3	.7	.3	78.2	12.1	0.0	0.0	0.0	1.4
6/15	265	0.0	0.0	3.8	3.8	0.0	77.3	13.6	0.0	.4	0.0	1.1
6/17	257	.4	0.0	7.8	5.8	0.0	68.1	16.7	0.0	.4	0.0	.8
6/19	298	0.0	0.0	7.1	1.3	0.0	74.2	17.1	0.0	0.0	0.0	.3
6/22	258	0.0	0.0	8.1	.8	0.0	69.8	19.4	.4	.4	0.0	1.1
6/24	278	0.0	0.0	6.5	.7	0.0	63.7	28.0	.4	0.0	0.0	.7
6/28	254	0.0	0.0	2.8	.8	0.0	54.7	41.3	0.0	0.0	0.0	.4
7/ 1	239	0.0	0.0	3.8	1.3	.4	40.6	53.1	.4	.4	0.0	0.0
7/ 3	265	0.0	0.0	2.7	1.1	0.0	39.6	56.2	0.0	0.0	0.0	.4
7/ 6	253	0.0	0.0	.4	2.0	0.0	26.5	70.7	0.0	0.0	0.0	.4
7/ 9	234	0.0	0.0	1.3	3.8	.4	18.4	74.8	1.3	0.0	0.0	0.0
7/12	254	0.0	.4	1.2	3.1	0.0	18.5	76.0	.4	0.0	.4	0.0
7/21	252	0.0	0.0	1.6	7.5	.4	14.7	73.4	2.0	0.0	.4	0.0
7/30	254	0.0	2.7	1.6	15.7	.8	14.2	64.2	.8	0.0	0.0	0.0
8/ 4	248	0.0	0.0	1.2	14.1	.8	8.9	75.0	0.0	0.0	0.0	0.0
8/13	273	0.0	.4	1.1	19.0	0.0	8.8	70.0	0.0	0.0	.7	0.0
8/25	128	.8	0.0	2.3	21.1	0.0	14.8	60.2	.8	0.0	0.0	0.0
8/27	125	0.0	0.0	1.6	17.6	.8	20.8	59.2	0.0	0.0	0.0	0.0

Appendix Table 6c. Age composition of sockeye salmon scale samples collected at Black Lake outlet during 1981, by percent of sample.

Sample Date	Sample Size	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/ 9	128	0.0	0.0	8.6	.8	0.0	78.1	10.9	0.0	0.0	0.0	1.6
6/10	222	0.0	0.0	16.2	1.8	0.0	71.6	9.0	0.0	0.0	0.0	1.4
6/12	193	0.0	0.0	6.7	2.6	0.0	74.1	15.6	0.0	0.0	0.0	1.0
6/13	181	0.0	0.0	13.3	.5	0.0	72.9	12.2	0.0	0.0	0.0	1.1
6/21	182	0.0	0.0	6.6	1.6	0.0	73.1	18.7	0.0	0.0	0.0	0.0
6/22	177	0.0	0.0	6.2	0.0	0.0	81.4	12.4	0.0	0.0	0.0	0.0
Mean		0.0	0.0	9.60	1.22	0.0	75.20	13.13	0.0	0.0	0.0	0.85

Appendix Table 6d. Summary of the daily and cumulative return of sockeye salmon for the Black Lake stock in 1981.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 5/31	9,773	0	9,773	9,773	.008
5/31	9,706	0	9,706	19,479	.017
6/ 1	8,817	0	8,817	28,296	.024
6/ 2	20,995	0	20,995	49,291	.043
6/ 3	31,105	0	31,105	80,396	.069
6/ 4	47,323	0	47,323	127,719	.110
6/ 5	67,104	0	67,104	194,823	.168
6/ 6	51,219	309	51,528	246,351	.213
6/ 7	21,227	0	21,227	267,578	.231
6/ 8	1,930	67,098	69,028	336,606	.291
6/ 9	3,440	32,797	36,237	372,843	.322
6/10	1,796	40,694	42,490	415,333	.359
6/11	958	28,047	29,005	444,338	.384
6/12	1,362	28,987	30,349	474,687	.410
6/13	10,843	5,212	16,055	490,742	.424
6/14	23,037	5,922	28,959	519,701	.449
6/15	2,561	26,925	29,486	549,187	.474
6/16	395	20,764	21,159	570,346	.493
6/17	388	19,533	19,921	590,267	.510
6/18	2,244	32,452	34,696	624,963	.540
6/19	2,308	22,891	25,199	650,162	.562
6/20	6,685	4,701	11,386	661,548	.572
6/21	9,401	7,803	17,204	678,752	.586
6/22	13,044	7,325	20,369	699,121	.604
6/23	3,815	9,365	13,180	712,301	.615
6/24	603	31,786	32,389	744,690	.643
6/25	3,156	13,825	16,981	761,671	.658
6/26	9,724	4,229	13,953	775,624	.670
6/27	10,734	0	10,734	786,358	.679
6/28	8,086	145	8,231	794,589	.686
6/29	10,357	0	10,357	804,946	.695
6/30	9,703	0	9,703	814,649	.704
7/ 1	8,530	19,172	27,702	842,351	.728
7/ 2	2,876	15,639	18,515	860,866	.744
7/ 3	2,344	17,130	19,474	880,340	.761
7/ 4	6,120	2,313	8,433	888,773	.768
7/ 5	3,206	21,709	24,915	913,688	.789
7/ 6	1,030	25,703	26,733	940,421	.812
7/ 7	652	26,297	26,949	967,370	.836
7/ 8	536	22,782	23,318	990,688	.856
7/ 9	541	27,333	27,874	1,018,562	.880
7/10	553	35,117	35,670	1,054,232	.911
7/11	685	14,476	15,161	1,069,393	.924
7/12	388	9,585	9,973	1,079,366	.932
7/13	327	13,440	13,767	1,093,133	.944
7/14	440	13,966	14,406	1,107,539	.957
7/15	835	5,979	6,814	1,114,353	.963
7/16	517	8,096	8,613	1,122,966	.970
7/17	454	8,162	8,616	1,131,582	.978
7/18	1,554	2,825	4,379	1,135,961	.981
7/19	1,427	2,411	3,838	1,139,799	.985
7/20	258	4,683	4,941	1,144,740	.989
7/21	313	3,021	3,334	1,148,074	.992
After 7/21	1,115	8,330	9,445	1,157,519	1.000
Total	438,540	718,979	1,157,519		

Appendix Table 6e. Summary of the daily and cumulative return of sockeye salmon for the Chignik Lake stock in 1981.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/10	89,638	63,002	152,640	152,640	.086
6/10	1,590	36,050	37,640	190,280	.107
6/11	1,035	30,257	31,292	221,572	.124
6/12	1,520	32,332	33,852	255,424	.143
6/13	12,489	6,004	18,493	273,917	.153
6/14	27,386	7,039	34,425	308,342	.173
6/15	3,137	32,993	36,130	344,472	.193
6/16	422	22,247	22,669	367,141	.206
6/17	363	18,424	18,787	385,928	.216
6/18	2,076	30,040	32,116	418,044	.234
6/19	2,066	20,477	22,543	440,587	.247
6/20	6,307	4,436	10,743	451,330	.253
6/21	9,357	7,765	17,122	468,452	.262
6/22	13,721	7,702	21,423	489,875	.274
6/23	4,347	10,669	15,016	504,891	.283
6/24	729	38,232	38,961	543,852	.305
6/25	4,031	17,656	21,687	565,539	.317
6/26	13,081	5,694	18,775	584,314	.327
6/27	15,094	0	15,094	599,408	.336
6/28	11,790	215	12,005	611,413	.343
6/29	15,132	0	15,132	626,545	.351
6/30	14,119	0	14,119	640,664	.359
7/ 1	12,296	27,642	39,938	680,602	.381
7/ 2	4,837	26,292	31,129	711,731	.399
7/ 3	4,634	33,887	38,521	750,252	.420
7/ 4	11,076	4,182	15,258	765,510	.429
7/ 5	5,374	36,388	41,762	807,272	.452
7/ 6	1,616	40,360	41,976	849,248	.476
7/ 7	1,093	44,237	45,330	894,578	.501
7/ 8	971	41,290	42,261	936,839	.525
7/ 9	1,062	53,707	54,769	991,608	.556
7/10	1,237	78,459	79,696	1,071,304	.600
7/11	1,754	37,069	38,823	1,110,127	.622
7/12	1,142	28,404	29,546	1,139,673	.639
7/13	1,047	42,916	43,963	1,183,636	.663
7/14	1,522	48,191	49,713	1,233,349	.691
7/15	3,128	22,383	25,511	1,258,860	.705
7/16	2,115	32,987	35,102	1,293,962	.725
7/17	2,022	36,383	38,405	1,332,367	.746
7/18	7,623	13,847	21,470	1,353,837	.759
7/19	7,747	13,098	20,845	1,374,682	.770
7/20	1,566	28,354	29,920	1,404,602	.787
7/21	2,141	20,602	22,743	1,427,345	.800
7/22	2,664	22,503	25,167	1,452,512	.814
7/23	2,635	15,974	18,609	1,471,121	.824
7/24	1,289	10,632	11,921	1,483,042	.831
7/25	1,267	9,300	10,567	1,493,609	.837
7/26	1,821	9,407	11,228	1,504,837	.843
7/27	1,562	16,550	18,112	1,522,949	.853
7/28	1,528	14,435	15,963	1,538,912	.862
7/29	2,389	14,066	16,455	1,555,367	.871
7/30	2,321	15,295	17,616	1,572,983	.881
7/31	1,613	12,517	14,130	1,587,113	.889
8/ 1	1,613	5,795	7,408	1,594,521	.893
8/ 2	1,613	6,215	7,828	1,602,349	.898
8/ 3	1,613	11,252	12,865	1,615,214	.905
8/ 4	1,613	10,223	11,836	1,627,050	.912
After 8/ 4	41,935	115,838	157,773	1,784,823	1.000
Total	392,909	1,391,914	1,784,823		

Appendix Table 7a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1982.

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
5/22	0	0	0	0	0	0	0	0	0	0
5/23	0	0	0	0	0	0	0	0	0	0
5/24	0	0	0	0	0	0	0	0	0	0
5/25	0	0	0	0	0	0	0	0	0	0
5/26	0	0	0	0	0	0	0	0	0	0
5/27	0	0	0	0	0	0	0	0	0	0
5/28	0	0	0	0	0	0	0	0	0	0
5/29	0	0	0	0	0	0	0	0	0	0
5/30	18	0	0	0	0	0	0	0	0	18
5/31	120	0	0	0	0	0	0	0	0	120
6/ 1	174	0	0	0	0	0	0	0	0	174
6/ 2	72	0	0	0	0	0	0	0	0	72
6/ 3	414	0	0	0	0	0	0	0	0	414
6/ 4	251	0	0	0	0	0	0	0	0	251
6/ 5	1,221	0	0	0	0	0	0	0	0	1,221
6/ 6	699	0	0	0	0	0	0	0	0	699
6/ 7	157	0	0	0	0	0	0	0	0	157
6/ 8	661	0	0	0	0	0	0	0	0	661
6/ 9	14,142	0	0	0	0	0	0	0	0	14,142
6/10	9,556	0	0	0	0	0	0	0	0	9,556
6/11	21,182	0	0	0	0	0	0	0	0	21,182
6/12	10,634	0	0	0	0	0	0	0	0	10,634
6/13	39,650	0	0	0	0	0	0	0	0	39,650
6/14	66,515	0	0	0	0	0	0	0	0	66,515
6/15	38,689	0	0	0	0	0	0	0	0	38,689
6/16	73,801	0	0	0	0	0	0	0	0	73,801
6/17	150,974	0	0	0	0	0	0	0	0	150,974
6/18	37,890	299,415	0	0	0	0	0	0	0	337,305
6/19	5,410	101,674	0	0	0	0	0	0	0	107,084
6/20	12,399	109,762	3,555	0	0	1,130	0	0	0	126,846
6/21	4,794	89,557	0	993	0	10,626	0	0	0	105,970
6/22	3,174	44,803	7,059	3,134	0	0	0	0	0	58,170
6/23	12,054	50,459	4,808	4,638	86	4,944	0	0	0	76,989
6/24	9,413	66,967	1,671	3,913	0	25,079	0	0	0	107,043
6/25	3,116	44,962	1,668	3,569	0	32,099	0	0	0	85,414
6/26	2,061	69,103	5,624	398	0	9,702	0	0	0	86,888

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Appendix Table 7a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1982 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
6/27	8,138	31,623	4,152	180	0	44,590	0	0	0	88,683
6/28	6,828	41,002	0	0	0	21,961	0	0	0	69,791
6/29	5,560	43,511	0	631	0	3,454	0	0	0	53,156
6/30	2,398	32,396	500	620	0	4,496	0	0	0	40,410
7/ 1	4,173	0	1,665	287	0	0	0	0	0	6,125
7/ 2	31,110	0	0	157	0	0	0	0	0	31,267
7/ 3	21,207	377	0	0	0	0	455	0	0	22,039
7/ 4	23,703	86	0	0	0	0	12	0	0	23,801
7/ 5	12,215	0	0	0	0	0	3,928	1	0	16,144
7/ 6	12,448	0	0	0	0	0	0	0	0	12,448
7/ 7	3,641	64,828	0	0	0	0	0	0	0	68,469
7/ 8	2,636	19,351	0	0	0	0	0	0	0	21,987
7/ 9	2,920	18,085	555	0	0	0	0	0	0	21,560
7/10	522	19,867	0	0	0	0	1,790	0	0	22,179
7/11	620	265	361	474	0	0	1,735	0	0	3,455
7/12	1,461	0	57	88	0	495	0	0	0	2,101
7/13	1,642	0	149	0	0	2,876	0	0	0	4,667
7/14	2,039	338	0	0	0	3,194	1,181	0	0	6,752
7/15	7,553	0	0	0	0	2,741	137	0	0	10,431
7/16	4,221	0	0	0	0	0	828	0	0	5,049
7/17	10,024	0	0	0	0	0	0	0	0	10,024
7/18	13,970	0	0	0	0	0	0	0	0	13,970
7/19	9,862	0	0	0	0	0	0	0	0	9,862
7/20	17,856	414	0	0	0	0	2,268	0	0	20,538
7/21	13,631	0	0	0	239	0	2,241	21	0	16,132
7/22	17,374	0	0	0	0	0	1,400	0	0	18,774
7/23	11,296	400	0	0	0	0	0	0	0	11,696
7/24	6,960	43	0	4	0	0	0	0	0	7,007
7/25	1,251	29,833	0	136	6	0	0	0	0	31,226
7/26	737	10,055	0	0	0	0	713	0	0	11,505
7/27	1,034	8,655	0	0	0	0	1,017	10	0	10,716
7/28	2,935	0	0	0	0	0	604	20	0	3,559
7/29	3,517	0	0	0	0	0	151	0	0	3,668
7/30	2,995	0	0	682	0	0	0	0	0	3,677
7/31[1]	1,613	0	0	0	0	0	0	0	0	1,613
8/ 1	1,613	0	282	0	0	0	0	0	0	1,895

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Appendix Table 7a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1982 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
8/ 2	1,613	0	923	726	0	0	1,008	2	0	4,272
8/ 3	1,613	6,586	994	610	0	0	1,179	10	0	10,992
8/ 4	1,613	4,503	495	824	0	0	1,377	0	0	8,812
8/ 5	1,613	4,511	557	0	0	0	1,294	165	0	8,140
8/ 6	1,613	522	1,833	1,827	0	0	1,320	23	0	7,138
8/ 7	1,613	0	0	890	0	0	326	39	0	2,868
8/ 8	1,613	0	0	0	83	0	0	19	0	1,715
8/ 9	1,613	8,355	0	0	0	0	0	0	0	9,968
8/10	1,613	4,208	0	0	0	0	0	0	0	5,821
8/11	1,613	4,209	882	1,442	0	0	824	0	0	8,970
8/12	1,613	89	97	96	0	0	819	10	0	2,724
8/13	1,613	604	724	201	4	894	1,098	20	0	5,158
8/14	1,613	0	1,852	901	0	0	866	46	0	5,278
8/15	1,613	0	0	320	0	0	1,117	6	0	3,056
8/16	1,613	6,922	0	0	1	0	0	0	0	8,536
8/17	1,613	6,584	574	0	0	0	90	0	0	8,861
8/18	1,613	5,393	477	506	0	0	131	0	0	8,120
8/19	1,613	0	203	635	2	0	245	0	0	2,698
8/20	1,613	3,675	0	425	0	0	0	0	0	5,713
8/21	1,613	2,693	0	0	0	0	0	0	0	4,306
8/22	1,613	1,286	0	0	0	0	0	0	0	2,899
8/23	1,613	10,742	0	0	0	0	0	0	0	12,355
8/24	1,613	5,469	0	1,934	0	0	0	0	0	9,016
8/25	1,613	9,250	208	220	0	0	42	0	0	11,333
8/26	1,613	7,125	0	674	0	0	0	0	0	9,412
8/27	1,613	7,666	63	394	0	0	0	0	0	9,736
8/28	1,613	800	0	239	0	0	11	0	0	2,663
8/29	1,613	131	0	0	0	0	0	0	0	1,744
8/30	1,610	19,840	0	0	0	0	0	0	0	21,450
8/31	0	7,960	0	0	0	0	0	0	0	7,960
9/ 1	0	9,763	0	0	0	0	0	0	0	9,763
9/ 2	0	5,858	0	10	0	0	42	0	0	5,910
9/ 3	0	7,859	0	541	0	0	9	181	0	8,590
9/ 4	0	10,059	0	174	0	0	0	284	0	10,517
9/ 5	0	5,397	0	330	0	0	0	0	0	5,727
9/ 6	0	4,055	0	0	0	0	0	132	0	4,187

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Appendix Table 7a. Chignik daily sockeye salmon escapement, catch by area, and total run adjusted to Chignik Lagoon date, 1982 (continued).

Date	Escapement	Chignik Lagoon	Hook Bay/ Kujulik	Aniakchak	Eastern District	Cape Igvak	Western District	Perryville District	Stepovak	Daily Total
9/ 7	0	3,868	0	0	0	0	0	125	0	3,993
9/ 8	0	3,966	0	0	0	0	0	0	0	3,966
9/ 9	0	2,995	0	25	0	0	0	0	0	3,020
9/10	0	2,855	0	108	0	0	0	0	0	2,963
9/11	0	2,221	0	76	0	0	0	0	0	2,297
9/12	0	987	0	0	0	0	0	0	0	987
9/13	0	1,060	0	0	0	0	0	0	0	1,060
9/14	0	1,306	0	0	0	0	0	0	0	1,306
9/15	0	535	0	0	0	0	0	0	0	535
9/16	0	1,037	0	0	0	0	0	0	0	1,037
9/17	0	623	0	0	0	0	0	0	0	623
9/18	0	1,354	0	0	0	0	0	0	0	1,354
9/19	0	1,675	0	0	0	0	0	0	0	1,675
9/20	0	1,042	0	0	0	0	0	0	0	1,042
9/21	0	657	0	0	0	0	0	0	0	657
9/22	0	1,242	0	0	0	0	0	0	0	1,242
9/23	0	1,408	0	0	0	0	0	0	0	1,408
9/24	0	1,099	0	0	0	0	0	0	0	1,099
9/25	0	227	0	0	0	0	0	0	0	227
9/26	0	579	0	0	0	0	0	0	0	579
9/27	0	0	0	0	0	0	0	0	0	0
9/28	0	0	0	0	0	0	0	0	0	0
9/29	0	89	0	0	0	0	0	0	0	89
9/30	0	0	0	0	0	0	0	0	0	0
Total	837,718	1,400,770	41,988	34,032	421	168,281	30,258	1,114	0	2,514,582 [2]

Appendix Table 7b. Age composition of sockeye salmon scale samples collected in Chignik Lagoon during 1982, by percent of sample.

Sample Date	Sample Size	Age 1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/ 7	255	0.0	0.0	1.6	0.0	0.0	90.2	3.9	0.0	.4	0.0	3.9
6/11	257	0.0	0.0	2.0	0.0	0.0	88.7	7.0	0.0	0.0	0.0	2.3
6/16	217	0.0	0.0	.9	.5	0.0	87.6	6.9	0.0	0.0	0.0	4.1
6/20	249	0.0	0.0	4.4	.4	0.0	84.4	7.6	0.0	0.0	0.0	3.2
6/24	223	0.0	.5	4.0	0.0	0.0	86.1	7.6	0.0	0.0	0.0	1.8
6/28	240	.4	.4	3.7	1.7	0.0	84.6	8.8	0.0	0.0	0.0	.4
6/30	233	0.0	.8	3.9	1.3	0.0	82.0	11.2	0.0	0.0	.4	.4
7/ 3	194	0.0	0.0	3.1	2.6	0.0	77.3	16.5	0.0	.5	0.0	0.0
7/ 7	240	.8	0.0	2.5	2.9	0.0	67.1	25.5	0.0	.8	0.0	.4
7/10	243	0.0	.4	2.5	5.8	0.0	52.7	37.0	0.0	.8	.8	0.0
7/14	255	0.0	0.0	2.4	10.6	0.0	28.2	58.4	.4	0.0	0.0	0.0
7/20	250	0.0	1.2	.8	6.0	0.0	20.4	70.0	.8	0.0	.8	0.0
7/25	236	0.0	.8	1.7	12.7	0.0	19.1	63.1	1.3	0.0	1.3	0.0
8/ 9	221	.4	3.2	1.4	11.3	0.0	6.3	74.2	0.0	1.4	1.8	0.0
8/23	237	.4	0.0	.4	8.0	0.0	7.6	82.7	0.0	0.0	.9	0.0

Appendix Table 7c. Age composition of sockeye salmon scale samples collected at Black Lake outlet during 1982, by percent of sample.

Sample Date	Sample Size	Age										
		1.1	2.1	1.2	2.2	3.2	1.3	2.3	3.3	1.4	2.4	Other
6/22	182	0.0	0.0	4.9	1.7	0.0	81.3	10.4	0.0	0.0	0.0	1.7
6/26	226	0.0	0.0	4.4	0.0	0.0	76.1	15.1	0.0	0.0	0.0	4.4
7/ 3	311	0.0	0.0	2.3	0.0	0.0	81.0	12.5	0.0	0.0	0.0	4.2
7/ 6	259	0.0	0.0	2.3	.8	0.0	84.2	9.2	0.0	0.0	0.0	3.5
Mean		0.0	0.0	3.48	0.62	0.0	80.65	11.80	0.0	0.0	0.0	3.45

Appendix Table 7d. Summary of the daily and cumulative return of sockeye salmon for the Black Lake stock in 1982.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/ 9	3,787	0	3,787	3,787	.002
6/ 9	14,142	0	14,142	17,929	.010
6/10	9,556	0	9,556	27,485	.015
6/11	21,182	0	21,182	48,667	.026
6/12	10,634	0	10,634	59,301	.032
6/13	39,650	0	39,650	98,951	.053
6/14	66,515	0	66,515	165,466	.089
6/15	38,689	0	38,689	204,155	.109
6/16	72,497	0	72,497	276,652	.148
6/17	148,087	0	148,087	424,739	.227
6/18	37,109	293,238	330,347	755,086	.404
6/19	5,291	99,417	104,708	859,794	.460
6/20	12,104	111,721	123,825	983,619	.527
6/21	4,681	98,786	103,467	1,087,086	.582
6/22	3,099	53,708	56,807	1,143,893	.613
6/23	11,775	63,427	75,202	1,219,095	.653
6/24	9,197	95,384	104,581	1,323,676	.709
6/25	3,032	80,066	83,098	1,406,774	.753
6/26	1,996	82,179	84,175	1,490,949	.798
6/27	7,850	77,703	85,553	1,576,502	.844
6/28	6,559	60,486	67,045	1,643,547	.880
6/29	5,069	43,397	48,466	1,692,013	.906
6/30	2,068	32,776	34,844	1,726,857	.925
7/ 1	3,419	1,600	5,019	1,731,876	.927
7/ 2	24,109	122	24,231	1,756,107	.940
7/ 3	15,480	608	16,088	1,772,195	.949
7/ 4	15,901	66	15,967	1,788,162	.958
7/ 5	7,479	2,405	9,884	1,798,046	.963
7/ 6	6,896	0	6,896	1,804,942	.967
7/ 7	1,807	32,164	33,971	1,838,913	.985
7/ 8	1,097	8,052	9,149	1,848,062	.990
7/ 9	989	6,315	7,304	1,855,366	.994
7/10	137	5,720	5,857	1,861,223	.997
7/11	131	603	734	1,861,957	.997
7/12	240	106	346	1,862,303	.997
7/13	197	364	561	1,862,864	.998
7/14	165	382	547	1,863,411	.998
7/15	536	204	740	1,864,151	.998
7/16	258	50	308	1,864,459	.998
7/17	522	0	522	1,864,981	.999
7/18	607	0	607	1,865,588	.999
7/19	348	0	348	1,865,936	.999
After 7/19	1,230	156	1,386	1,867,322	1.000
Total	616,117	1,251,205	1,867,322		

Appendix Table 7e. Summary of the daily and cumulative return of sockeye salmon for the Chignik Lake stock in 1982.

Date	Escapement	Catch	Daily Return	Cumulative Return	Cumulative Proportion
Prior 6/18	4,191	0	4,191	4,191	.006
6/18	781	6,177	6,958	11,149	.017
6/19	119	2,257	2,376	13,525	.021
6/20	295	2,726	3,021	16,546	.026
6/21	113	2,390	2,503	19,049	.029
6/22	75	1,288	1,363	20,412	.032
6/23	279	1,508	1,787	22,199	.034
6/24	216	2,246	2,462	24,661	.038
6/25	84	2,232	2,316	26,977	.042
6/26	65	2,648	2,713	29,690	.046
6/27	288	2,842	3,130	32,820	.051
6/28	269	2,477	2,746	35,566	.055
6/29	491	4,199	4,690	40,256	.062
6/30	330	5,236	5,566	45,822	.071
7/ 1	754	352	1,106	46,928	.073
7/ 2	7,001	35	7,036	53,964	.083
7/ 3	5,727	224	5,951	59,915	.093
7/ 4	7,802	32	7,834	67,749	.105
7/ 5	4,736	1,524	6,260	74,009	.114
7/ 6	5,552	0	5,552	79,561	.123
7/ 7	1,834	32,664	34,498	114,059	.176
7/ 8	1,539	11,299	12,838	126,897	.196
7/ 9	1,931	12,325	14,256	141,153	.218
7/10	385	15,937	16,322	157,475	.243
7/11	489	2,232	2,721	160,196	.247
7/12	1,221	534	1,755	161,951	.250
7/13	1,445	2,661	4,106	166,057	.257
7/14	1,874	4,331	6,205	172,262	.266
7/15	7,017	2,674	9,691	181,953	.281
7/16	3,963	778	4,741	186,694	.288
7/17	9,502	0	9,502	196,196	.303
7/18	13,363	0	13,363	209,559	.324
7/19	9,514	0	9,514	219,073	.338
7/20	17,369	2,606	19,975	239,048	.369
7/21	13,334	2,447	15,781	254,829	.394
7/22	17,088	1,378	18,466	273,295	.422
7/23	11,174	396	11,570	284,865	.440
7/24	6,922	47	6,969	291,834	.451
7/25	1,251	29,975	31,226	323,060	.499
7/26	737	10,768	11,505	334,565	.517
7/27	1,034	9,682	10,716	345,281	.533
7/28	2,935	624	3,559	348,840	.539
7/29	3,517	151	3,668	352,508	.545
7/30	2,995	682	3,677	356,185	.550
7/31	1,613	0	1,613	357,798	.553
8/ 1	1,613	282	1,895	359,693	.556
8/ 2	1,613	2,659	4,272	363,965	.562
8/ 3	1,613	9,379	10,992	374,957	.579
8/ 4	1,613	7,199	8,812	383,769	.593
8/ 5	1,613	6,527	8,140	391,909	.605
8/ 6	1,613	5,525	7,138	399,047	.617
8/ 7	1,613	1,255	2,868	401,915	.621
8/ 8	1,613	102	1,715	403,630	.624
8/ 9	1,613	8,355	9,968	413,598	.639
8/10	1,613	4,208	5,821	419,419	.648
8/11	1,613	7,357	8,970	428,389	.662
8/12	1,613	1,111	2,724	431,113	.666
After 8/12	29,031	187,116	216,147	647,260	1.000
Total	221,601	425,659	647,260		

Appendix Table 8. Scale characters examined for the in-season linear discriminant function analyses.

First lacustrine annular zone	
Character	Definition
1	distance from the scale focus to the first circulus in the zone
2	distance form the scale focus to the fifth circulus in the zone
3	the ratio of the distance between the first circulus before the end of the zone and the end of the zone to the width of the zone
4	distance between circuli 2 and 3
5	distance between circuli 3 and 4
6	the ratio of character 5 to the width of the zone
7	distance between circuli 1 and 5
8	first circulus of the widest pair in the zone
Second lacustrine annular zone	
1	distance from the end of the first lacustrine annulus to the first circulus in the zone
2–4	distance between every consecutive pair of circuli between the second and fifth circuli in the zone
5–6	distance between every second circulus between the second and fifth circuli in the zone
7	distance between circuli 2 and 5